The effect of forest type and time of day on bird activity and diversity in a cloud forest

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Abstract

Forest type and time of day as variables affecting birds have been studied vastly with results supporting both variables having an effect (Fontúrbel, *et al*. 2021 & Robbins, 1981). However, very few studies have taken place within a cloud forest, and they have shown no significant effects between time of day and forest type on bird activity or diversity (van Riessen, 2021 & Tovar Heid, 2023). Here, 8 study sites comprised of four different forest types were sampled from 07:30 to 16:30 recording all visual and audio bird activity. Results supported previous findings within cloud forests, concluding no effect between forest type or time of day on bird activity or diversity. It is suggested to carry out similar studies at different cloud forest sites. Alternatively, looking at the effect of the makeup of each site through variables such as vegetation and amount of direct sunlight especially within a study site containing intertwined forest types is also suggested.

Introduction

Birds are a great indicator of the forest and overall environmental health. They are susceptible to anthropogenic change, rely on insects as a large part of their diet and are generally well-known and recorded so changes are noticeable (Gregory & van Strien 2010). A decline in bird species will negatively affect important ecosystem processes such as seed dispersal and pollination, causing knock-on effects. This highlights the importance of further research, ensuring negative changes are noticed quicker (Şekercioğlu, *et al*. 2004).

Despite birds being well studied, avian knowledge in cloud forests is not, largely due to this environment being uncommon and compact. Tropical montane cloud forest ecosystems make up just 2.5% of all tropical forests, and in the Americas, cloud forests make up as few as 1.2% of all tropical forests. Despite this, these ecosystems harbour outstanding levels of biodiversity with 10% of the world's restricted range (range of less than 50,000km^2) bird species mainly found in cloud forests (Long, 1995). Classifying as a cloud forest requires specific climatic conditions such as high altitude, which paired with their small, fragmented distribution makes them a very vulnerable ecosystem and particularly susceptible to anthropogenic pressures (Ponce-Reyes, *et al*. 2012). Climate change threatens changes in temperature and rainfall which reduces cloud forests as their range will be restricted to higher altitudes that still contain their characterised conditions. Monteverde, a part of the

Talamancan mountain range in Costa Rica, has shown signs of being negatively affected by climate change experiencing a reduction in cloud immersion (Foster, 2001). In Peru, 32% of the 272 mammal, frog, and bird species are endemic to the cloud forests (Leo, 1995; Bubb, *et al*. 2004). The high level of endemism in montane cloud forests makes them both a priority to conserve and a very important study site. By furthering the research of these ecosystems, we can closely monitor endemic species and as a result gauge the overall condition of the environment.

Time of day and bird activity has been studied for numerous years, with global census occurring and overall records increasing yearly. The knowledge of early mornings, specifically sunrise, being synonymous with high bird activity has been known for some time. A previous study (Robbins, 1981) showed that bird activity rapidly increased between an hour before sunrise and sunrise itself. Both the number of species and individuals peaked between one and two hours after sunrise and then declined. However, this supplies only a general guideline. In practice, each location and each day brings its own unique set of factors that can affect bird activity.

Habitat, and specifically forest type can largely dictate bird diversity and activity. A recent study (Fontúrbel, *et al*. 2021) into bird activity showed how forest type can largely influence bird activity patterns with old-growth, plantation, and secondary forests all showing varied activity peaks. Many of these differences are due to the habitat structure enabling what behaviour can occur within it (Mancke & Gavin, 2000). For example, older forest types have better canopy cover providing better nesting sites, (McCoy & Bell, 1991) whereas younger forest types may have a larger abundance of fruiting plants promoting larger frugivore species abundance (Blake & Loiselle, 1991). Early successional forest types attract high species diversity as trees do not dominate, instead plants such as ferns and shrubs flourish resulting in a changing varied area (Swanson, *et al*. 2011).

Weather can greatly influence bird activity, particularly rain and wind, as well as any extreme changes; for example, drastic temperature drops are shown to have large negative effects on activity (Robbins, 1981). Rain is not only unfavourable for birds due to the cold and wetness, but it can also have a negative effect on the insect population as well as decrease the air pressure (Johnson & Worobec 1988). Due to these sensitive factors, bird activity can be very different across not only different habitats but over different periods of the same habitat.

Methodology

Study area

Cloudbridge Nature Reserve, a part of the Talamancan mountain range, in the south of Costa Rica, is home to a tropical montane forest. Purchased in 2002 Cloudbridge, previously used as pastureland, began being reforested. This history provides Cloudbridge, now more than 20 years later, with over 60 acres of four different forest types which include primary, natural regeneration old and young, and planted. Information on the forest types at Cloudbridge is as follows: planted growth is a maximum of 21 years old; natural young regeneration is a maximum of 30 years old; old growth natural regeneration is over 30 years old; primary forest is at least 76 years old.

Across the reserve 8 sites were chosen as survey sites, comprising all 4 forestry types including 2 planted sites, 2 young and planted sites, 2 old growth sites and 2 primary forest sites (see fig. 1). No sites were purely young growth based on planted growth being strongly present at those sites. Some young growth was present at the planted sites however the area was dominated by planted growth. The specific age of each tree a bird landed on was not recorded as it was the site as a whole that was looked at. All sites were chosen based on prior high bird activity recorded and potential high bird activity related to each forest type. Each point count involved an epicentre allowing movement up to 20m~ away and birds within a 50m~ radius were recorded. These distances were based on judgement and not accurately measured. Sampling was broken up into 4 time periods, 07:30-09:30, 09:30-11:30, 12:30-14:30, and 14:30-16:30. Two sites were sampled a day with a 2-hour morning sample and a 2-hour afternoon sample. Primary forest sites (Site 7 and 8) were sampled for four hours, meaning both morning or afternoon time periods in one sitting, due to the time to get to and from the sites. During sampling, birds were recorded by visuals and audio, making note of which. Birds seen outside the 50m were still recorded, however, another species and individual list was created, allowing for totals with and without them. The total number of individuals unidentified was noted. Each identification was based on the certainty it was that species. Unidentified individuals were defined as any bird that was seen within the area and could not be identified down to the species level.

Date, site number, species, scientific name, family, number of individuals, time, and method of identification (seen or heard) were recorded. In addition, the date, site, survey start time, survey end time, total species and individuals found with and without birds that flew over, and the number of unidentified individuals were recorded.

Site details

Site 1 Planted growth. Located early on the El Jilguero trail. Narrow trail. Tree cover and partially open. Noise from cicadas is often present. Distance to water 0.1km. N: 09*28.230 W:083*34.706 Z:1665m

Site 2 Old-growth. Located halfway up the El Jilguero trail. Narrow trail. Strong tree cover with minimal openness. Distance to water 0.2km. N:09*28.109 W:083*34.473 Z:1849m

Site 3 Planted growth. Located on the West side of Rio. A wide site next to the trail. Minimal tree cover and very open. Noise from the adjacent river is very present. Distance to water <0.1km. N:09*28.292 W:083*34.292 Z:1693m

Site 4 Planted and young growth. Located on the East side of Rio. A wide site next to the trail. Minimal tree cover and very open. Noise from the adjacent river is very present. Distance to water <0.1km. N:09*28.484 W:083*34.189 Z:1690m

Site 5 Planted and young growth. Located before Entrada Oeste into Rio. Wide trail. Minimal tree cover and very open. Noise from the river below is present. Distance to water <0.1km. N:09*28.372 W:083*34.283 Z:1722m

Site 6 Old-growth. Located halfway along Heliconia. Narrow restrictive trail. Strong tree cover and minimal openness. Situated on the edge of the canopy. Distance to water <0.1km. N:09*28.347 S:083*34.469 Z:1636m

Site 7 Primary Forest. Located at the end of El Jilguero. Narrow trail. Very strong tree cover and limited openness. Elevation 1965m. Distance to water 0.2km. N:09*27.998 W:083*34.281 Z:1967m

Site 8 Primary Forest. Located on the Chirripó trail just before it meets the end of Montaña. Large wide trail. Strong tree cover and very open. Distance to water 0.4km. Coordinates N:09*27.892 W:083*33.981 Z:2205m

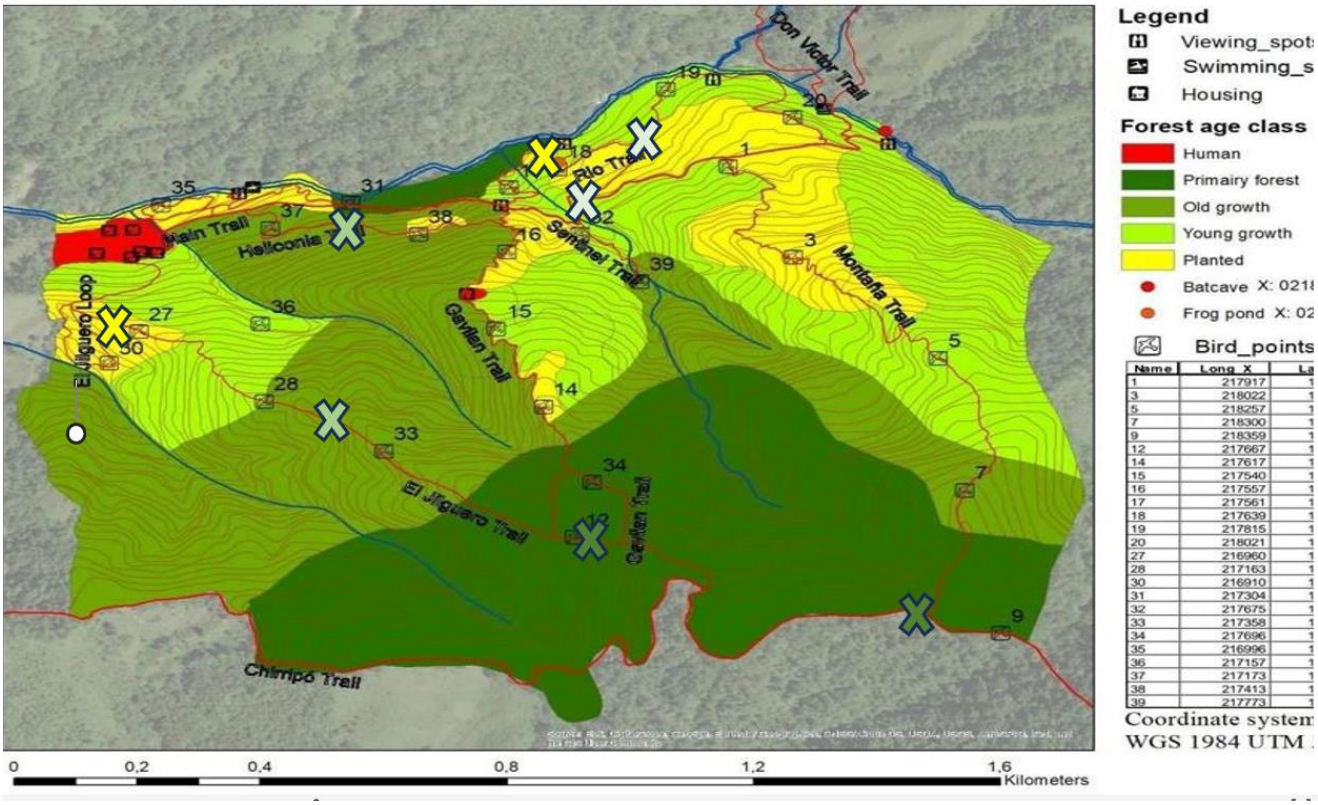

Figure 1: A map of Cloudbridge Nature reserve showing all 8 site locations and their respective forest types.

Results

At the end of data collection, 1653 individuals from 101 species were surveyed over 201 hours cumulatively across the 8 sites. When looking at the effect of forest type, time slot and site all tests conducted were Kruskal-Wallis tests due to the data being discrete.

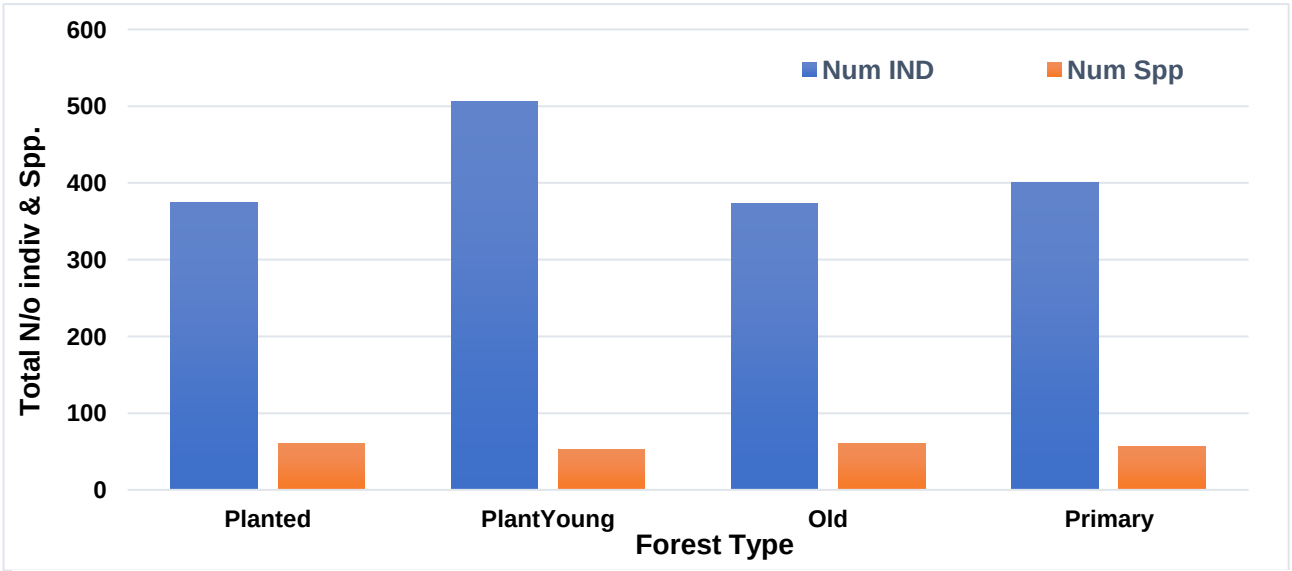

Figure 2: The total number of individuals and species found at each forest type.

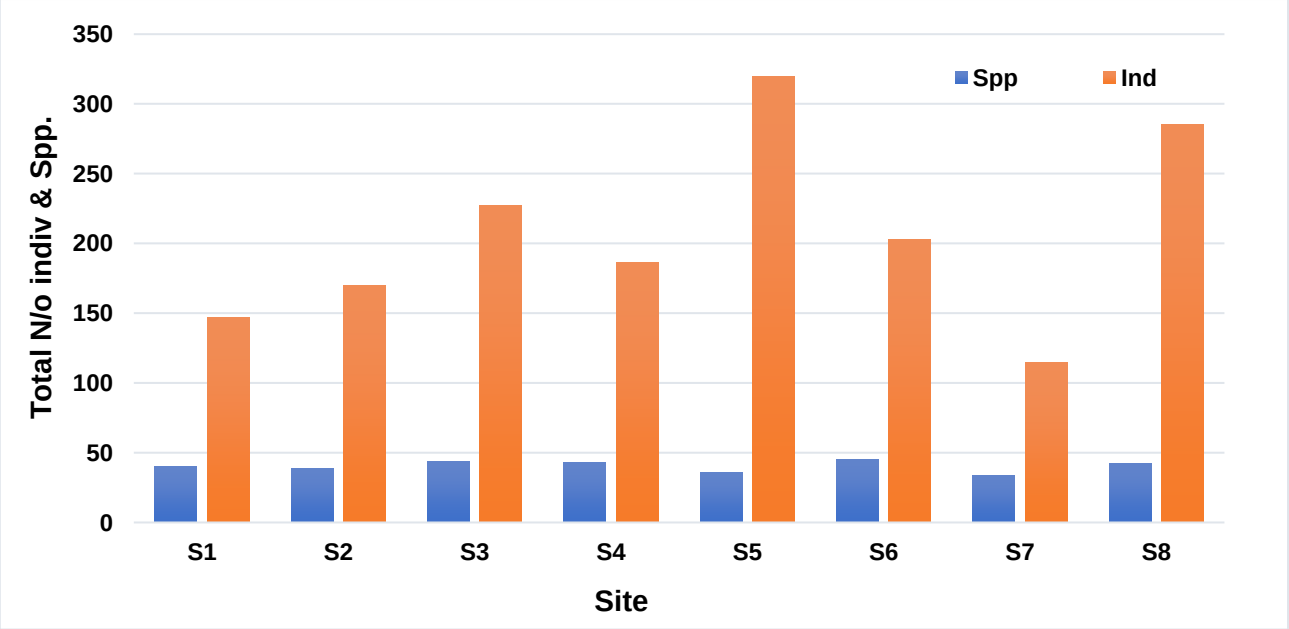

Figure 3: The total number of individuals and species found at each site.

Figure 2 shows that individuals varied between sites with site 5 recording 320 individuals, 320% more than site 7. The Kruskal-Wallis test showed that any variations in the total and average number of individuals at different sites were not significantly different. Planted and young growth has noticeably higher individuals found than the other forest types (see fig. 3). After testing it was found forest type had no effect on the total and average number of individuals recorded at each forest type. The average number of species found was not influenced by forest type or site and showed little variance.

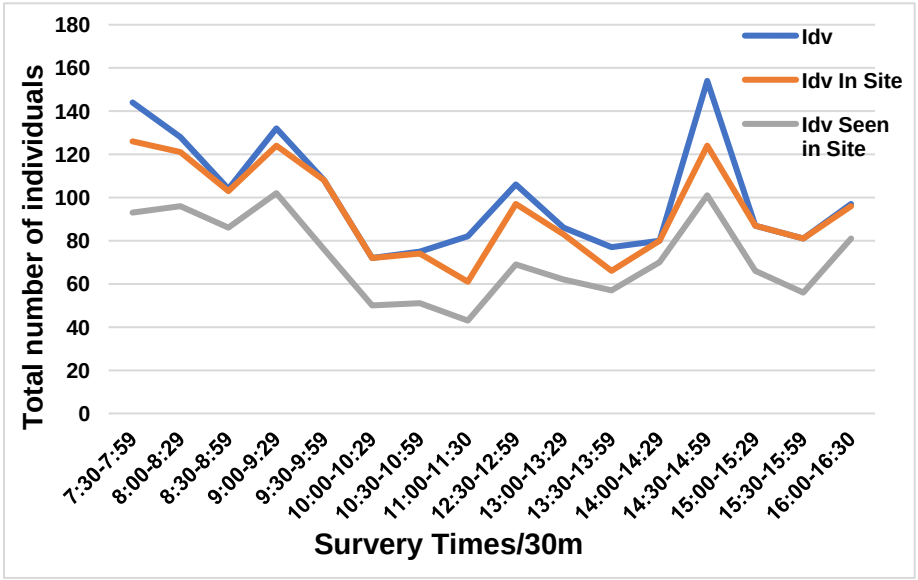

Figure 4: An activity time graph, showing the total number of individuals every 30 minutes. Each two-hour time slot was split into four 30-minute periods.

Figure 4 shows bird activity begins high between 7:30-7:59 with 144 individuals. This drops to 103 until 9:00-9:29 which shows a rise to 132 individuals. This rapidly declines up to midday. A noticeable rise after midday is followed by a steady decline until 14:30-14:59 where activity peaks at 154 individuals. Activity drops for the next hour until 16:00-16:30 when activity increases again.

Forest type, time slot and site were insignificant on the total number of individuals, species and unidentified recorded. There was, however, a significance between time and the average number of individuals recorded per sighting (p= 0.0109). A Dunn's post hoc test showed time slot number four (14:30-16:30) produced significantly more average individuals per sighting than time slot two (9:30-11:30), giving a p-value of 0.0009 converted to 0.0053 after the Bonferroni p adjustment method. This p-value adjustment considers the number of comparisons to ensure the p-value is not due to chance ("Bonferroni Correction", 2015).

Total	Forest Type	Time slot	Site
Species	0.5201	0.123	0.0859
Individual	0.7267	0.089	0.1924
Unidentified	0.3655	0.6261	0.1186

Table 1: Kruskal-Wallis p values showing the effect of forest type, time and site on the total number of species, individuals and unidentified.

Discussion

My results showed forest type and time of day did not significantly affect the total bird activity. This does not support previous findings, which show time and forest type can interactively affect bird activity. A recent study by Fontúrbel, *et al*. 2021, found that different forest types affected the peak bird activity. Although, the main differences were between strongly disturbed or altered forest types and old-growth forest types. Forest types within Cloudbridge have not been disturbed since 2002 when the reforestation of the area began. Despite not all areas being directly planted at this time it shows the environment becoming more stable, potentially explaining the lack of preference for birds in forest type. Previous research at Cloudbridge has also shown the lack of statistical significance between forest type and bird activity and similar findings (see fig. 2) with bird activity being the highest in young growth (van Riessen, 2021). However, through this method, it is hard to gauge which forest types birds rely on and prefer. Birds can be seen across all different forest types especially when the changes are gradual and so close to each other. As well as this, just because a bird uses or is seen more in one forest type does not necessarily mean it is more crucial for the survival of that species. For example, the Resplendent Quetzal was recorded at every forest type apart from planted. We know they prefer higher altitudes and established environments, however from just my results determining this would be a bold inference. It is hard to find the forest type preference for birds unless studying each one individually, with a

general study the amount you see a species in one forest type at certain times is your best indication. Even if my results showed significance within forest type, these conclusions would still have major drawbacks. The main drawback is the bias and number of sites. I picked my sites based on potential bird activity, this included looking at previous research and my own bird knowledge. This could mean some forest types were not low on bird activity and instead, the locations chosen were poor. Potentially there are good and bad bird activity sites within each forest type, this along with other factors, such as trail and altitude, means I should have not only included more sites per forest type but also spread them across the whole reserve. This as well as looking at morning and afternoon time may not have been achievable for one researcher; however, I believe it is necessary to conclude accurate and representative findings.

My results show on average between 14:30-16:30 you are more likely to see more individuals in one recording than at 9:30-11:30. This suggests birds of the same species are more likely to be in groups. As it comes closer to dusk communication about weather and returning the nest is more necessary, whereas the lead-up to midday may see many solitary individuals foraging before they return to nests at midday.

Figure 4 shows bird activity sloping downwards after the first survey, suggesting that there may have been a higher peak of bird activity prior to the start time at 7:30 am. Bird activity is known to be high shortly after sunrise (Robbins, 1981). Research conducted at Cloudbridge has shown through 40-minute point counts, bird activity peaks at 6:55-7:35 am. Despite this also concluding time of day was not statistically significant on bird activity, earlier survey times should have been introduced into the methodology (Tovar Heid, 2023). The reasons were a mix of achievability and some areas within the valley of the mountains not receiving sunlight until later. However, there is a huge amount of data missed out on and not all of the sites were in valleys so comparisons between them potentially would have differed further. This could be argued for the hours before sunset. Figure 4 also shows an upward trajectory at 16:30 pm. Again, more data is always helpful in making conclusions, although practically this would be harder in this environment with clouds disturbing visibility very early; however, with available time, surveying up until sunset would be recommended as well.

Figure 4 shows the largest peak in bird activity to be between 14:30-14:59. This was very surprising and may be specific to this area and those similar to the unique climate. It is likely this peak is due to rain often falling in the early afternoon, therefore this period comes after it has rained for some time meaning the birds become active again. As well as this, clouds often begin to appear as early as 15:00 and so perhaps birds are making use of the last bit

of direct sunlight before it is clouded over. These are only inferences from this study and there is no evidence to support this.

Although the site was not statistically significant on bird activity, figure 3 shows large variations. Site 5 has more than double the number of individuals than site 7. This could be due to the make-up of these sites, with site 5 being very open with great visibility. Whereas site 7 is enclosed with tall overpowering trees making visibility very difficult. This could mean that site 7 only appears less active as it is harder to identify birds. The unidentified numbers do not support this; however, it is harder to see individuals within the primary forest so there may be birds in the area which are not being seen. A more realistic conclusion is that the ecology makeup is influencing these results, this includes the location, altitude and distance to water. Figure 3 suggests this with all three of the lowest total number of individuals being found within the same trail. At Cloudbridge, research has shown the trail to be statistically significant on bird activity (Tovar Heid, 2023). Figure 3 also supports the ineffectiveness of forest type with the four most active sites being at all four different forest types.

A large limitation of this research was bird identification. Bird identification began at an average of 50%, although this improved to 80% by the end of this research, meaning a large proportion of birds both individuals and species would have been missed out on. This success was also dependent on the day, weather and direct sunlight interfered with the ability to identify birds. This was not measured and was randomly present. The temperature was also not recorded, unfortunately, as the local weather station only recorded temperature and precipitation once a week and other methods were not accurate. It is possible temperature along with sunlight exposure is a large factor in bird activity both of which were not recorded in this study. There are many other factors not recorded in this study that have been shown to indicate influences on bird activity such as light intensity and humidity (Rajpar & Zakaria, 2015).

Conclusion

The time of day within a cloud forest does not significantly affect bird activity. Forest type requires more in-depth research; however, others have also shown it to be ineffective (van Riessen, 2021; Tovar Heid, 2023). I recommend looking more in-depth at the effect of the make-up of each site, such as sunlight exposure and vegetation, on the bird species. To better look at the effect of forest type, I would suggest an alternative study site with more distinct forest-type barriers. Within a stable environment where forest types are so mixed, other climate effects may be even more influential than already shown previously, giving a large importance to trails and specific locations (Rajpar & Zakaria, 2015). Therefore, factors such as temperature and weather are recommended to improve this study. A baseline

knowledge of the avian species should be established before data collection begins to limit the number of unidentified individuals. Additionally, having multiple people during sampling and someone to take photographs would further increase identification success.

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