**Grading Rubric:**

To receive full credit for your work at the Exploration Seminar in Peru you should have completed the following (120 pts. total):

1. Pre-course reading and research (online quiz answers and project proposal) (10 pts.)
2. Biodiversity topic presentation (10 pts.)
   * Summary of required topic and some relevant examples from E.O. Wilson reading (5)
   * Facilitation of discussion, and integration of outside ideas/readings (5)
3. Active participation during the Seminar activities (20 pts.)
   * Participation in discussion (including being an active member in the above presentation) (5)
   * Participation in activities (10)
   * Field project presentation (5)
4. Daily Journal (40 pts.)
   * Organization and clarity (10)
   * Observations/facts/data/daily challenges (15)
   * Reflections/interpretations/synthesis (15)
5. Formal Paper (40 pts.): max 5 pages single-spaced, 12 pt font (not including literature citations). Please number your pages. Please give us a self-evaluation of your contribution to the project (see guidelines below). An abstract of your paper in Spanish is required. Three sample student papers are attached, and can be used as a reference on how to organize and present yours .You must submit a draft of your paper for feedback before you turn the final version in. References from the primary literature and figures are required.. Your paper will be a group paper and we won’t accept more than one paper on the same project

6. Please, fill in the specific Peru Seminar evaluation (not graded, but required—will not be read by us until after grades are turned in).

**Peru Exploration Seminar**

**Paper writing guidelines**

Here are some important guidelines that will help in having a good quality paper. Please notice that the deadline to submit a strong rough draft is in mid October (exact date tbd) (we highly encourage this so that you can get feedback from us), and the final draft is due in early November (exact date tbd). Both drafts should be submitted to the respective dropbox by midnight of the deadline.

In general assume the reader knows little about what you did and why. Explain the study in such a way that any person could repeat the study based on your explanations.

Write each section of your paper and stop, read your paper aloud—you will often catch sentence fragments and incomplete thoughts when you do this and then keep writing. "Good writing is rewriting," and you should dedicate effort for editing, rewriting, and fine-tuning before you give the draft to anyone else to read (which is highly recommended). Ask that person if your paper makes sense. Does he/she understand what you did?

**Style:**  For writing this paper use ACTIVE VOICE, meaning that you will write your sentences using “I” or “We” and describe your work. One of the criticisms to this style is the presence of many short sentences that start with I or WE. One trick to avoid this is using phrases like, “Our results demonstrated”, “These results demonstrated our predictions”, and so on.

Avoid wordy phrasing, such as sentences that start with “In order to…” In this case, just start with “To…” For example, “To test X, we did Y”. For more style tips, scroll down. Also, remember that this is a group paper, and although it may originally be prepared in parts by each member of the group, it is the group’s responsibility to edit the first draft and proofread more than once, so the whole document flows smoothly and it is easier to read as one full piece.

**Self-evaluation on the group paper:** Considering that you are turning in a group paper, we want to make sure we are fair when we grade you individually. For this reason, we ask to discuss as a group and come up with the percent contribution of each group member. This percentage may not exclusively measure the time invested by each group member, but may also assess the quality and content of each individual’s contribution.

At the end of the paper, provide a list of the group members’ name and the percent contribution assigned after discussing together. DO not send emails for individual evaluations for each member. We only want to see one that ALL of you agree on.

**General tips for each of the sections of a scientific paper**

**Title**: Give a meaningful one that reflects the study, and that it is catchy and sounds interesting.

**Abstract (both in English and Spanish):** This section should be 200 words max. The abstract should provide one or two sentences about the rationale and goals of your project, a brief description of methods, results and the main points of the discussion. The abstract should have a grammatically correct Spanish version of approximately the same length.

**Introduction:** Care should be taken to limit the background to whatever is pertinent to the study. A good introduction will answer several questions, including: What is the main topic of this study? Why was this study performed?

What knowledge already exists about this subject? The answer to these questions include the revision of references and primary literature, showing the historical development of an idea and including the confirmations, conflicts, and gaps in existing knowledge. What is the specific purpose of the study?

The specific question for your study should be described. Provide background and context for the study, and then the specific questions being asked. Mention the common name(s) of the species followed by the Latin name(s) italicized and in parentheses when you introduce the species. From then on, consistently use either the common or scientific name but not both.

**Methods:** The difficulty in writing this section is to provide enough detail for the reader to understand the procedures without being overwhelming. When additional methods from a previous work have been used, simply cite the work, noting that details can be found in that particular source. However, it is still necessary to describe the most important properties of the method or the general theory about it. This can usually be done in a short paragraph. One more thing: this section is written in past tense and also should provide a narrative of what you did, not as a set of instructions of what “students were told to do”. Please, avoid details that are not relevant.

**Results:** Just the facts! Don’t be redundant within the results sections unless you have a good reason for it. Don’t show raw data—summarize in a table or figure. Don’t discuss the implications of your data (you do that in Discussion), but briefly explain in the text the observed trends and comparisons referring to tables and figures you are preparing with your results. Data included in a table should not be duplicated in a figure or graph.

**Discussion:** Develop a strategy for your Discussion. Many people wrongly begin the Discussion section with a statement about problems with their methods or the parts of their results about which they feel least confident. Unless these problems (e.g., biases, skewed data, etc.) are the most important thing about your research, save them for later. Begin the discussion with a short restatement of the most important points from your results. Start with what you can say clearly based on what you did, not what you cannot say or what you did not do. Use this statement to set up the ideas you want to focus on in interpreting your results and relating them to the literature. You also need support from primary literature (scientific papers or published literature/books etc.; not webpages since many times those don’t have scientific support). This is also a good place to put your research back into a broader context. Talk about further implications and future research directions. If you didn’t show what you expected, don’t immediately assume your experiment was flawed or that your sample size was too small. Maybe, despite a small sample size, you uncovered something novel—talk about the implications. If your data are so limited that there is virtually nothing to talk about, feel free to talk about what you expected to find, why you didn’t find it, and link it back to the theories you talked about in your introduction.

## References should be cited in the text, putting author’s name and year in parentheses, and then organized in the references section in alphabetical order by author’s last name. See attached sample paper for guidelines. Five to ten references is enough—we would prefer that you actually read and understand the references you cite rather than just “padding” the paper with extra references. Note that we expect references from primary literature.

**Figures and tables** need to have a descriptive title— titles for them should not merely name a table or figure, they should explain how to read it. Have a correlative numeration both in the text and in the figures/table section (do not need to have a heading for figures/tables).

**Additional comments:**

- Remember that written English is different from spoken English, avoid slang and try to be formal without being boring.

* Avoid …”shows” and replace with “demonstrates”.
* AVOID all these expressions: “As you can see” or “As one can see”, “much different”, ‘quite different’, “The fact that”, “It makes sense” or “It makes sense that there is”, ”is clearly evident”.—Instead show the evidence with your actual results. Avoid vague phrases or relative comparisons.

- Avoid using day names (Tuesday and Thursday)—use Day 1/Day 2 or the first survey/2nd survey or something else

- Avoid “very” ”fairly large”— cite the actual numbers to understand the comparison.

- Avoid ‘Also’ at the start of sentences, use ”Furthermore, In addition or Additionally”

- Avoid “this data” just write “the data”..also DATA ARE/WERE…not data is/was (data= plural for datum)

- (Figure X) can be written as (Fig. X).

- Finally, please save paper (and trees.). Do not use extra pages without reason and try to use the space efficiently. Two figures in the appropriate size could go in the same page….we’re just trying to re-awaken the conservationist on you.

Below: Sample student papers with our comments on it (double click the purple highlighting to see what we wrote on the paper):

**Spider Diversity Across Peruvian Amazon**

ABSTRACT: Our study was undertaken to investigate spider diversity across several microhabitats in the area surrounding our Puerto Maldonado research station. We collected samples from several plots of varying vegetation, disturbance, and soil composition: river side plot, secondary forest plot, and a road side plot. Among these, it was anticipated that the highest diversity of families would occur in the secondary forest habitat, followed by the areas of lower vegetational coverage. Owing to a number of variables, especially the type of trap used for capturing the specimens, our sample sizes were limited. As a result of this and other factors we were given rather inconclusive results. Several families were captured during the study, and the significant majority of these spiders were recovered from the traps at the road side plot. The paucity of specimens from the other plots suggests that ground-based traps are a largely ineffective means of capturing spiders, at least in a highly layered environment such as the Amazon rainforest.

Nuestro estudio fue emprendido a investigar diversidad de araña a través de varios microhabitats en el área que rodea nuestra estación de investigación de Puerto Maldonado. Reunimos muestras de varios complots de variar vegetación, del alboroto, y de composición de tierra: complot de lado de río, complot secundario de bosque, y un complot de lado de camino. Entre éstos, fue anticipado que la diversidad más alta de géneros ocurriría en el hábitat secundario de bosque, seguido por las áreas de alcance más bajo de vegetational. Debiendo a varias variables, especialmente el tipo de trampa utilizada para captar las especímenes, nuestros tamaños de la muestra fueron limitados. A consecuencia de este y otros factores nosotros fuimos dados resultados bastante no decisivos. Varios géneros fueron captados durante el estudio, y la mayoría significativa de estas arañas fue recuperada de las trampas en el complot de lado de camino. La escasez de especímenes de los otros complots sugiere que esas trampas suelo-basados son un medios en gran parte ineficaces de captar arañas, por lo menos en un ambiente sumamente estratificado como la pluviselva de Amazonas.

INTRODUCTION: The main topic of this study was to study spider diversity among various microhabitats in the forest around Puerto Maldonado to gain a better understanding of how different species of spiders employ different strategies to adapt to their environment. This study was performed to sample existing spider species inhabiting the Peruvian Amazon. This is important to develop a baseline of spider species richness from which we can develop better questions regarding ecology and conservation of these organisms. There has been a great deal of arthropod sampling throughout the Amazon basin (Hoefer et. al. 1994), though due to the significant level of arthropod diversity in the Amazon there are new species of spiders discovered frequently (Aviles et. al. 2001). Studies of spider sociality appear rather common (Lubin and Bilde 2007) and some research has looked at effects such as altitudinal variation on fundamental species characters such as behavior and physiology (Aviles et. al. 2001). However it has been somewhat difficult to find general studies of Amazonian spider diversity or more specific studies across microhabitats in a given area, as our project attempted to do.

Our original intention was to make a comparison of diversity across an altitudinal gradient, investigating both species found in the cloud forest at Wayqecha field station and then the Amazon basin. However we lacked the resources necessary to adequately compare individuals found in the two regions, and as a result we decided a simpler study of diversity could still provide interesting results. We hypothesized that species diversity would increase as the amount of forest cover increased, which would result in high levels in the secondary forest and lower levels in the more exposed areas of the river side and road side. In our sampling we attempted to capture a broad range of species by using pit-fall traps and eye shine counts. The families that we captured include crab spiders (*Thomisidae)*, the wolf spiders (*Lycosidae)*, and the jumping spiders (*Salticidae)* as well as two unidentified families. We were not able to identify specimens to the genus or species level.

METHODS: We used two different sampling techniques to determine species abundance and diversity. These included light shine eye counts and pit-fall traps. When using the light shine count we measured three plots of 1 X 3 meters and shined our light at 7:00 p.m. in the dark to count the number of eye reflections characteristic of spiders. This gave us the abundance of spiders in the plot. This was done once in all three plots in each of the sample areas. In addition to this we used pit-fall traps to capture spiders traveling along the ground. Three plastic cups were placed one meter apart in each of the three plots. Three nails were placed around the outside of the cup and a piece of tree bark was placed on top of the nails to prevent rain and debris from entering the cup. A small amount of water was placed in the bottom of each cup and a small amount of detergent was placed in the water to break the surface tension and prevent the spiders from escaping. The pit-fall traps were left out during the three days of the study and were sampled six times throughout the study. Each time the cups were sampled the water and detergent were replaced.

RESULTS:

|  |  |  |
| --- | --- | --- |
|  | Spider Abundance in Different Microhabitats | |
| Area | # of Spiders | # of Families |
| 1A | 0 | 0 |
| 1B | 0 | 0 |
| 1C | 0 | 0 |
| 2A | 1 | 1 |
| 2B | 0 | 0 |
| 2C | 0 | 0 |
| 3A | 0 | 0 |
| 3B | 3 | 2 |
| 3C | 7 | 4 (2 unknown) |
|  | 11 individuals | 5 families |

Fig. 1.

|  |  |
| --- | --- |
| Eye Shine Counts | |
| Area | Frequency of Individuals |
| 1 | 6 |
| 2 | 6 |
| 3 | 22 |

Fig. 2.

In both Fig. 1 and 2 there are three areas shown. Area 1 is river side, area 2 is secondary forest, and area 3 is road side. Area 3 had a significantly larger frequency of spider captures and eye shine counts than the two other areas. This held true for both the pit-fall tests and the eye shine counts. In total 11 individuals were found during the course of the study belonging to at least 5 families, two of which we were unable to identify during the course of the field work.

DISCUSSION: Our investigation was negatively impacted by several variables beyond our control. One day experienced substantial rainfall, which presumably inhibited spiders from leaving shelter and moving into the pit-fall traps. The traps themselves may have been an ineffective means of capturing spiders, because many species encountered in the rainforest are likely arboreal (Floren and Deelernan-Reinhold 2005). With the light shine counts we were not able to determine family of the spiders counted. We were also limited in our counts to the spiders which were facing our direction, and presumably the spiders whose eyes were not contacted by the light from our flashlight were not included in the count. Observations over a larger number of days would have been beneficial in that we would have had larger overall samples and more statistically significant data to work with. We were limited by the lack of arachnid reference materials in the field which hampered our ability to identify spiders beyond the family level.

Based on our inconclusive results, spider abundance was highest in the road side microhabitat, which ran contrary to our original hypothesis. We encountered significantly more individual spiders and families of spiders in that environment, perhaps suggesting that ground dwelling spiders are not abundant in forest or river side environments in our test area. Ground dwelling spiders may preferentially select for habitat which has a higher level of unobstructed area (i.e. less ground cover). Following the lines of our research an important direction to take would be to more specifically categorize the different families and species to give a more accurate sense of spider diversity in the region. It would also be interesting to do surveys of spider diversity in recently disturbed areas verses primary forest (e.g. Floren and Deelernan-Reinhold 2005). Focused research of individual species and the ways in which they have adapted to their microhabitat have been elucidated in studies such as that of Dias and Machado (2006), but in terms of applying such research to conservation or broader scale ecological questions more integrative studies should take place. Our originally intended study would still be an interesting avenue of future research, that is, to compare spider biology along an altitudinal gradient (e.g. Aviles et. al. 2001), and investigate the different variables in these environments that might affect the ways in which spiders utilize their habitats.

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Member Contributions: Jane Doe: 50%, John Doe: 50%

Peruvian Hummingbird Wing Length to Body Weight Ratios Across an Altitudinal Gradient

**Abstract**

The morphological diversity among Peruvian birds is incredible, and many studies have been done to determine the causes of these morphological diversities. The geography of Peru spans a large altitudinal range, and this prompted the question of whether or not there is a relationship between wing length and body weights of hummingbirds (family Trochilidae) across this altitudinal gradient. We tested this hypothesis by mist netting at two different altitudes, and measuring the wing lengths and body weights of the hummingbirds caught. The data showed a positive trend between wing length to body weight ratios and altitude, with reasonably consistent ratios within each altitude. These trends are most likely caused by the decrease in atmospheric pressure and oxygen concentration at higher altitudes. Other potential causes are plant density, food diversity, or competition. Understanding physiological differences at different altitudes may be important in the near future as more and more species lose their habitats due to deforestation.

La diversidad morfológica de aves Peruanos es incredible. Muchos estudios han sido completados para determinar las causas de estas diferencias morfológicas. La geografia de Perú incluye una gran cantidad de alturas variadas, por eso investigamos si hay una relación entre la longitud de alas y el peso del cuerpo de picaflores (familia Trochilidae) a través la gradiente de alturas. Evaluemos la hipótesis con redes de neblinas a dos diferentes alturas. Los datos mostraron una moda positiva entre la longitud de alas y el peso de cuerpos de picaflores y la altura, con una coherencia razonable entre las proporciones por cada altura. Estas modas probablemente son causados por la disminuación de presión atmosférico y concentración de oxígeno en las locaciones mas altas. Otras causas potenciales son la densidad de plantas, la diversidad de comida, o la competición. Entendiendo las diferencias fisiológicas causados por el cambio de la altura puede ser importante para el futuro de las esepecies que estan perdiendo sus habitates.

**Introduction**

The geography of Peru covers a large range of altitudes, and hummingbirds are found almost everywhere, including both the cloud forests, as well as the Amazon. Most of the species are habitat specific, and there is a wide range of morphological diversity throughout the family Trochilidae. The presence of hummingbirds at vastly different altitudes prompted our question as to whether or not some of the morphological diversities were due to differences in flying habits as a result of the different altitudes. Studies by DL Altshuler showed that shorter winged hummingbirds were better able to compete at lower altitudes, but at higher altitudes, loner winged hummingbirds had the advantage (2006).

The physics of flying indicate that with lower air pressure, larger surface area is needed to provide enough lift for flight (Tipler and Mosca, 2008). The physics of mechanical flight should also hold true for avian flight as well, thus further supporting the hypothesis that wing length to body weight ratios should increase as altitude increases and atmospheric pressure decreases.

We focused our study on two different altitudes; the cloud forest at Wayqecha field station (3200m above sea level), and the Amazon at CECCOT field station (220m above sea level). The 4 hummingbird species we encountered at Wayqecha were Shining sunbeams (*Aglaeactis cupripennis*), Rufous-capped Thornbills (*Chalcostigma ruficeps*), Tyrian metaltails (*Metallura tyrianthina*), and Amythest-throated Sunangels (*Heliangelus amethysticollis*). In contrast, the 3 hummingbird species we captured at CECCOT were Fork-tailed woodnymphs (*Thalurania furcata*), Rufous-breasted hermits (*Glaucis hirsuta*), and White-necked Jacobins (*Florisuga mellivora*) (Schulenberg et. al., 2007). . Previous studies have shown that hummingbirds compensate for hypoxic conditions by morphologically increasing relative wing size and kinematically increasing stroke amplitude during wing stroke (Altshuler and Dudley, 2006). We were interested in further exploring the ratios of wing lengths to body weights seeing as these measurements are important for flight, and thus likely to change with altitude.

**Method**

Study Site - Samples were collected at Wayqecha field station (approximately 3200m above sea level) in Manú National Park, and CECCOT field station (approximately 220m above sea level) in Puerto Maldonado. At Wayeqcha, four nets were set up along the trocha Picaflor in near succession. During some trials, however, the top most net was not used because it was too close to our work site. At CECCOT, six nets were set up, two at three different locations. Two nets were set up near the river, two along side the path to the road (approximately 400m away from the river nets), and two were placed at the beginning of the trail system across the road (approximately 400 m away from the path nets.) All six nets were used in all of the trials. All nets were 6 or 12 meters long with a mesh size of 30 millimeters.

Bird Sampling – Samples were taken over two days at Wayqecha (day 1 and 2), and another two days at CECCOT (day 3 and 4). Each day we sampled in the morning from approximately 6:00 – 9:30 AM unless weather caused us to end early (Day 3). On day 1, we attempted to mist net in the afternoon, starting at 3:00 PM, however the weather conditions were not suitable, and the same was true for day 2. On day 3, we continued mist netting when the rain ended, at approximately 10:00 AM, and continued for 2 hours.

We checked the nets approximately every 30 minutes, and if there was a bird, we removed it from the net, and brought all the birds back to a work site. Here, many measurements were taken for all the birds, not just hummingbirds, but special attention was paid to hummingbird wing lengths and body weights. Once the birds were measured, they were released in the direction of where they were caught. At CECCOT, the rightmost tail wing was clipped, to indicate recapture (and the other birds were banded).

Data Analysis – Ratios were calculated by taking wing length divided by body weight. These ratios were plotted according to species, and conclusions were drawn from these figures. Average wing lengths and body weights per species were calculated, as well as the standard deviations of these averages depending on altitude. No statistical analysis was preformed.

**Results (insert figure/table mentions)**

During the two days of sampling at Wayquecha, 10 individual hummingbirds were caught and measured. The 10 individuals caught were comprised of 4 different species. During the two days of sampling at CECCOT, 7 individual hummingbirds were caught and measured. These 7 individuals consisted of three different species, none of which were the same as any of the species caught at Wayqecha.

The wing length to body weight ratios are similar across all 4 species at Wayqecha (Fig. 1), as well as for all 3 species at CECCOT (Fig. 2), however these ratios are not similar between the two locations. The ratios at Wayqecha are larger than those at CECCOT.



Figure 1: Wing length to body weight ratios according to hummingbird species found at Wayqecha field station (3200m). A total of 10 birds from 4 different species were caught and measured over 2 days.



Figure 2: Wing length to body length ratios according to hummingbird species found at CECCOT (220m). A total of 7 birds from 3 different species were caught and measured over 2 days.

Although the ratios of wing length to body weight are similar at Wayqecha, it is not due to a consistent similarity between wing lengths or body weights (Table 1). At CECCOT, there was a lot more homogeneity among individual wing lengths and body weights, as well as the ratios of the two (Table 2). The standard deviation of wing length at Wayqecha was 15, while the standard deviation of wing length at CECCOT was 5. The standard deviations for body weight are 1.5 and 1.0 respectively (Table 3).

Table 1: Average wing lengths and body weights per species at Wayqecha field station. Data does not include the outlier for the rufous-capped thornbills.

|  |  |  |  |  |
| --- | --- | --- | --- | --- |
|  | Wayqecha | | | |
|  | Shining Sunbeam | Rufous Capped Thornbill | Tyrian Metaltail | Amethyst Throated Sun Angel |
| Average Wing Length (mm) | 88 | 58.3 | 54 | 68 |
| Average Weight (g) | 6.7 | 3.9 | 3.5 | 6 |

Table 2: Average wing lengths and body weights per species at CECCOT.

|  |  |  |  |
| --- | --- | --- | --- |
|  | CECCOT | | |
|  | Forktailed Woodnymph | R-B Hermit | Jacobin |
| Average Wing Length (mm) | 54 | 60.6 | 64.5 |
| Average Weight (g) | 5.5 | 7.5 | 6 |

Table 3: Standard deviations calculated from the average wing lengths and body weights at Wayqecha and CECCOT.

|  |  |  |
| --- | --- | --- |
|  | Wayqecha | CECCOT |
| Average Wing Length Standard Deviation | 15.13 | 5.31 |
| Average Weight Standard Deviation | 1.56 | 1.04 |

**Discussion**

Although there appears to be consistency among the wing length to body weight ratios at Wayqecha, there are a few inconsistencies. One of the data points for the thornbill appears to be a significant outlier. This individual lost all its tail feathers while being removed from the mist net, and therefore, his weight was significantly lower than it would have been had he had all of his feathers. This could very well account for the more than twice as large wing length to body weight ratio. For this reason, we did not include this point when calculating average wing lengths or body weights for the thornbills. It is also of note that only one metaltail was caught, and this individual was a juvenile female. All of the rest of the individuals caught at Wayqecha were adult males. Although we captured mostly adult males, the data still demonstrate an apparent trend that should not be overlooked since which birds we caught was random.

The ratios in figure 2 also show apparent consistency, however there is less consistency of age and sex. Both of the Jacobins were juvenile, and one of the hermits was a female. The other four individuals were adult males. We do not see this as a source of error because within these three species, there is no significant size sexual dimorphism. One possible source of error is the sampling bias due to the net mesh size. We noticed that some of the smaller hummingbirds had flown almost all the way through the net, which leads us to believe that smaller birds would have been able to fly through the net without getting caught, thus skewing our data towards larger individuals. Although this is true, we did not have the means to set up various nets of different mesh sizes, but this factor could account for catching mostly adults.

We did not clip tail feathers of the hummingbirds caught at Wayqecha, but since we took many different measurements, all of which differed among the individuals, we feel we had no recaptures. At CECCOT, we clipped the rightmost tail feathers, and thus, are sure we had no recaptures.

The data demonstrate that wing length to body weight ratios are larger at higher altitudes than they are at lower ones. Some possible explanations we thought of are plant diversity, plant density, surface area to volume temperature regulation, and competition. Of these possibilities, the surface area to volume issue would predict smaller ratios at higher altitudes, while the rest predict larger ratios at higher altitudes. As surface area to volume increases, heat loss is a more prevalent issue, as is apparent in many small animals. In addition, it is known that temperature fluctuates more and drops to lower temperatures at higher altitudes than it does at lower temperatures in the Amazon. As a result, it was possible that hummingbirds at these higher altitudes would want smaller surface area to volume ratios in order to better conserve heat, but this does not appear to be true.

The three other proposed explanations are not mutually exclusive. There is more plant diversity and density in the Amazon than there is in the Peruvian cloud forests. This could lead to birds that do not need to fly as far to get food, and thus they have smaller niches and feeding grounds. The decreased need to fly far distances could have lead to a decrease in wing length to body weight ratios. Similarly, competition could lead to a need to fly farther distances to feed. For example, at Wayqecha, we caught flowerpiercers in the same locations as the hummingbirds, in addition to observing direct competition between the two. This competition could lead to hummingbirds needing larger feeding grounds since there isn’t as much food available, and thus larger wing length to body weight ratios. In the Amazon, we did not catch any flower piercers, or witness direct competition over food, which does not mean it doesn’t exist, but it might play a lesser role in the Amazon, where there is more abundance of different types of food.

Upon further consideration and research, it appears that there are other factors that may play a more significant role in hummingbird physiology across an altitudinal gradient. Specifically, behavior, migration, and air density may all lead to a difference in wing length to body weight ratios. Feeding habit behaviors differ in terms of perching or hovering when eating, and territory size. We predicted that birds who hovered while eating would have larger wing size to body weight ratios, as would those that had larger food territories. Migration could also play a role in these ratios, however, none of the seven species we caught are migratory birds, so this is a moot point.

Air density, on the other hand, plays a very large role in animal physiology. As one moves up an altitudinal gradient, air density decreases, and thus, the concentration of oxygen also decreases. The decrease in oxygen concentration has known effects on bird physiology, as shown by K.C. Welch in his studies on oxygen consumption rates and metabolism of hummingbirds across various altitudes (Welch, 2007). Since flight requires a large surface area to create enough pressure difference to create lift, the lighter the air is, the larger the surface area needs to be. This is because if the air is less dense, the same sized wing would create less pressure since it would encounter less resistance from the air. As a result, birds at increased altitudes need to have bigger wings in order to counteract the less dense air. This would result in a bigger wing length to body weight ratios at higher altitudes (Altshuler and Dudley, 2006). The trends we saw in our data are a starting point for possible future studies. A sample size of 17 is too small to extrapolate or generalize about Peruvian hummingbirds in any way. Also, the fact that samples were only taken for 2 days at each site poses more error due to possible seasonal differences in populations. Although there are many sources of possible error, the trends strongly indicate that as altitude increases, wing length to body weight ratios increase as well.

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October 24, 2008

Exploration Seminar Peru

The Effects of Natural and Human Disturbances on Tree Diversity in the Peruvian Amazon

**Abstract**

Within the Peruvian Amazon at the Tambopata Center for Conservation, Science and Education, or CECCOT, are several distinct sections of forests that vary in both tree density and species diversification due to natural and human disturbances in the area. The naturally disturbed section of forest was located nearest a tributary to the Amazon River on a historically flooded region of land. The increased diversity of tree species in the secondary forests on the other side of the field station proved to be a great contrast to few number of tree species found in the naturally disturbed area. Within the secondary forests, we noticed that human disturbances on the eastern border of the forest had also affected the tree composition of that region as compared to the undisturbed forests on the western end of the trails. In collecting data and comparing tree composition in these three forest areas, we measured two 50 meter transepts along each section of forest and then identified the tree family that each tree along the transept belonged to. Ultimately, we found that the undisturbed secondary forest contained the greatest diversity of tree families and the naturally disturbed area had the least number of tree families. By comparing the tree composition in each of these three sections, we can then examine the role that both natural and unnatural disturbances have played within the region.

**Resumen**

Dentro Amazonía Peruana, en el Centro para la Conservación, Educación y Ciencia Tambopata (CECCOT), existen distintas secciones de bosques que varían tanto en densidad de árboles como en diversidad de las especies, debido a los impactos naturales y antrópicos de la zona. La sección de bosque perturbada naturalmente se encuentra cercana al Rio Tambopata, (un afluente del río Amazonas) zona que es inundada anualmente. El aumento de la diversidad de especies arbóreas en los bosques secundarios en la zona elevada, muestra un gran contraste con las pocas especies encontradas la zona inundable. En el límite este de la propiedad, notamos la perturbación antrópica en el bosque secundario que también ha afectado la composición arbórea de esa zona, en comparación con el área no perturbada en el la zona oeste, al final de las trochas. Se midieron dos transectos de 50 metros a lo largo de cada sección de bosque para colectar e identificar las familias botánicas, luego se comparó la composición arbórea en cada sección. Finalmente, encontramos que el bosque secundario no perturbado tiene la mayor diversidad de familias arbóreas mientras que la zona perturbada naturalmente (inundable) tiene la menor diversidad. Al comparar la composición de árboles en cada una de estas tres secciones, podemos examinar el rol de las perturbaciones tanto naturales como no naturales dentro de la región.

**Introduction**

The study concerns the effects of natural and human disturbances on species diversification of trees in the forests surrounding CECCOT in the Peruvian Amazon. We conducted the study because we were interested in the process of forest succession following a human or natural disturbance. The concept of forest succession is a fundamental aspect of ecological succession and refers to the orderly change in composition of an ecological community. Succession initiated by a disturbance is best described as a secondary succession, which begins where soil is already present. While many factors may influence forest succession, forest communities in early succession are generally characterized by dominant, opportunistic species, including heliophytes, or “sun-loving,” plants and trees. Over time, these pioneering species will tend to be replaced by more competitive species, including “shade-tolerant” species that do not need direct sunlight to survive (Turner, Baker, Peterson, & Peet, 1998).

Researchers have yet to discover a general trend with regards to ecological succession. While many trends have been proposed, few apply broadly within the entire field of ecology (Connell & Slayter, 1977). In our study, we wanted to research whether a specific trend existed in the forest succession of the Peruvian Amazon. By comparing the tree composition of a naturally disturbed area of forest, a human-disturbed secondary forest, and an undisturbed secondary forest, we wanted to examine how species diversity of the trees in these three areas are related to one another and then derive a trend based upon these comparisons. Using our existing knowledge of forest succession, we hypothesized that speciation would increase over time following a disturbance as a few pioneer species are replaced by a wider number of competitive species. For example, we were interested in how heliophytes such as the trees in the *Cecropiaceae* family would fare in a naturally disturbed area compared to an undisturbed secondary forest. In our collection of data on the human disturbed region, we were concerned primarily about the comparison in tree composition from a cleared, artificial border of the forest with that of the undisturbed part of the secondary forest to the west.

Considering the time limitation on the study, we restricted the study to the identification of tree families found in a given region instead of the identification of unique species. We made the assumption that the number of tree families should be positively correlated to the number of tree species. Recording the number of tree families in one area thus allows us to estimate species diversification in a specific region. By examining the correlation of the overall composition of each region to the stage of succession of the respective region, we can then analyze a possible trend in regard to forest succession of the particular ecology.

**Methods**

We measured two 50 meter transepts at each of the three sections of forest near the CECCOT field station, which included the naturally disturbed forest nearest the river, the undisturbed secondary forest on the western end of the trails, and the human disturbed secondary forest located on the eastern border of the reserve. At each 50 meter transept, we limited the scope of the experiment to only established trees. Beginning at one of each transept, we attempted to identify the tree families of each of the established trees along the trail by examining leaf formation, fruits and flowers, characteristics of the bark, and overall appearance, among other defining tree qualities. We further used binoculars help us better examine leaves and a pocket knife to cut small bark samples so that we could look for signs of latex or sap. For any trees that we could not outright identify, we took pictures and leaf samples to identify using field guides back at the station. If we still were unable to identify the family, we recorded the tree as an “unknown” and marked it as so in our results.

**Results**

We took data along six transepts located near CECCOT in the Peruvian Amazon.

El Relojero

Las Abejas

CECCOT

River

Figure 1: Map of CECCOT and surrounding forests. Trails A-F represents the trails we measured transepts from.

Below are six tables detailing the number of unique plant family found along each of the trails:

**Table 1: Trees on 50m transept of Trail A Table 2: Trees on 50m transept of Trail B**

|  |  |  |
| --- | --- | --- |
| **Las Abejas (TA)** | **# of trees** | **% total trees** |
| Arecaceae | 3 | 15% |
| Fabaceae | 4 | 20% |
| Cecropiaceae | 2 | 10% |
| Moraceae | 1 | 5% |
| Annonaceae | 2 | 10% |
| Melastomataceae | 1 | 5% |
| Lauraceae | 2 | 10% |
| Rubiaceae | 1 | 5% |
| Morphospecie 1 | 1 | 5% |
| Morphospecie 2 | 1 | 5% |
| Morphospecie 3 | 2 | 10% |
|  | 20 | 100% |

|  |  |  |
| --- | --- | --- |
| **Relojero (TB)** | **# of trees** | **% total trees** |
| Cecropiaceae | 2 | 7.7% |
| Myristicaceae | 5 | 19.2% |
| Annonaceae | 5 | 19.2% |
| Tiliaceae | 1 | 3.8% |
| Moraceae | 2 | 7.7% |
| Arecaceae | 5 | 19.2% |
| Melastomataceae | 1 | 3.8% |
| Fabaceae | 1 | 3.8% |
| Bignoniaceae | 1 | 3.8% |
| Morphospecie 1 | 1 | 3.8% |
| Morphospecie 4 | 2 | 7.7% |
|  | 26 | 100.0% |

**Table 3: Trees on 50m transept of Trail C Table 4: Trees on 50m transept of Trail D**

|  |  |  |
| --- | --- | --- |
| **Near River (TC)** | **# of trees** | **% total trees** |
| Cecropiaceae | 17 | 50% |
| Moraceae | 10 | 29% |
| Fabaceae | 1 | 3% |
| Burseraceae | 2 | 6% |
| Morphospecie 5 | 2 | 6% |
|  | 34 | 100% |

|  |  |  |
| --- | --- | --- |
| **Near River (TD)** | **# of trees** | **% total trees** |
| Cecropiaceae | 33 | 68.8% |
| Burseraceae | 3 | 6.3% |
| Moraceae | 4 | 8.3% |
| Melastomataceae | 2 | 4.2% |
| Salicaceae | 2 | 4.2% |
| Morphospecie 5 | 2 | 4.2% |
| Morphospecie 6 | 2 | 4.2% |
|  | 48 | 100.0% |

**Table 5: Trees on 50m transept of Trail E Table 6: Trees on 50m transept of Trail F**

|  |  |  |
| --- | --- | --- |
| **Relojero (TE)** | **# Trees** | **% total trees** |
| Rubiaceae | 2 | 6.7% |
| Boraginaceae | 2 | 6.7% |
| Arecaceae | 6 | 20.0% |
| Cecropiaceae | 1 | 3.3% |
| Bombacaceae | 1 | 3.3% |
| Bignoniaceae | 3 | 10.0% |
| Fabaceae | 1 | 3.3% |
| Myrtaceae | 8 | 26.7% |
| Annonaceae | 3 | 10.0% |
| Myristicaceae | 1 | 3.3% |
| Moraceae | 1 | 3.3% |
| Morphospecie 7 | 1 | 3.3% |
|  | 30 | 100.0% |

|  |  |  |
| --- | --- | --- |
| **Las Abejas (TF)** | **# Trees** | **% total trees** |
| Arecaceae | 13 | 59.1% |
| Cecropiaceae | 2 | 9.1% |
| Bombacaceae | 1 | 4.5% |
| Moraceae | 1 | 4.5% |
| Fabaceae | 2 | 9.1% |
| Melastomataceae | 1 | 4.5% |
| Pipiraceae | 1 | 4.5% |
| Euphorbiaceae | 1 | 4.5% |
|  | 22 | 100.0% |

**Discussion**

Our results indicate that there exist noticeable differences among the tree composition in each of the three forest regions examined. Within Trail A, no family appeared very dominant. Table 1 shows that the *Fabaceae* family made up the highest percentage of total trees, but nonetheless represented only 20% of the total trees documented. By Table 2, we found only five trees in each of the *Myristicaceae, Annonaceae, and Areaceae* families, and then either one or two trees in the rest of the eleven families found along Trail B in the undisturbed forest. On either Trail A or Trail B, no family contributed more than 20% of the total trees found along those transepts. The relatively low number of trees found within a given family indicates a heightened level of competition among different trees for resources within each of the two regions.

Trails C and D were located in the naturally disturbed forest region nearest the tributary to the Amazon River. On Trail C, we documented only five unique families along a 50 meter transept compared to the eleven found on both Trail A and Trail B. Of those five families, by far the most dominant was the *Cecropeaceae* family, accounting for 50% of the total trees documented, followed by the *Moraceae* family with 29% of the total trees along the transept. The dominance of these trees within the *Cecropeaceae* and *Moraceae* families can be attributed to the fact that they are opportunistic heliophytes that can thrive in open, disturbed areas with sun (Connell & Slater, 1997). The massive floods that poured through the area just a few decades ago had presumably cleared much of the land to allow for such opportunistic trees and plants to continue to thrive in the region.

Trails E and F were located in the human disturbed region next to the cleared border of the property. While it is unclear to what extent humans have affected the area, the tree composition in this area is somewhat of a contrast to the undisturbed secondary forest at the other end of the trails. Trail E had 12 unique families of trees along the 50 meter transept. While Trail E indeed had more tree families than either A or B, there existed at least one dominant family, the *Myrtacaeae,* which accounted for 26.6% of the total trees documented. Thus unlike Trail A or B where no dominant families existed, Trail E had one family that seemed to prosper to a greater degree relative to the other 11 families present in the area. Similarly to Trail E, Trail F was dominated by one major family, *Areacaceae*, which accounted for 59.1% of the total trees in that region. While it is difficult to estimate how much of a factor human disturbance is on the overall tree composition of Trails E and F, our results demonstrated that there indeed exists a correlation between the artificial border and diminishing biodiversity among trees in that region.

In general, our results indicate that a major difference between the undisturbed secondary forests and both the naturally-disturbed and human-disturbed regions is the presence of dominant tree families in the disturbed forests. Existing research suggests that certain species usually appear first because they have evolved “colonizing” characteristics, including the ability to produce large numbers of seeds with good dispersal techniques, to survive in a dormant state for an extended period of time, to germinate quickly and establish themselves in unoccupied regions, and to grow and mature quickly. Furthermore, these species are not adapted to germinating, growing, and surviving in occupied regions, where there is heavy shade, litter, and competition for resources (Connell & Slayter, 1977). In our experiment, the “colonizing” characteristics are most evident in the *Cecropeaceae* family documented on both Trail C and D, which accounted for 50% and 68.8% of the trees on the two trails, respectively. The percentage of *Cecropeaceae* is a significant contrast to the percentage of *Cecropeaceae* found in the undisturbed Trails A and B, which only accounted for 10% and 7.7% of the trees on those two trails, respectively. The large difference in percentage of *Cecropeaceae* in these two regions is indicative of the increasing competitiveness, and thus biodiversity, of these surrounding forests over time.

The combination of both our primary research and outside resources indicate that there exists a correlation between disturbances and tree composition in the Peruvian Amazon in which biodiversity increases over time following a disturbance. In future experiments, we would pick a larger number of random transepts within each designated region in order to account for variance among different parts of each trail. We would also seek to compare the level of tree speciation within an undisturbed secondary forest to an undisturbed primary forest and observe the differences between the two regions.

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# Group:

# I wrote the entire paper with the exception of the Spanish abstract that Jane wrote. Jane, however, took charge of the primary research and data collection.

# Jane Doe: 50% John Doe: 50%