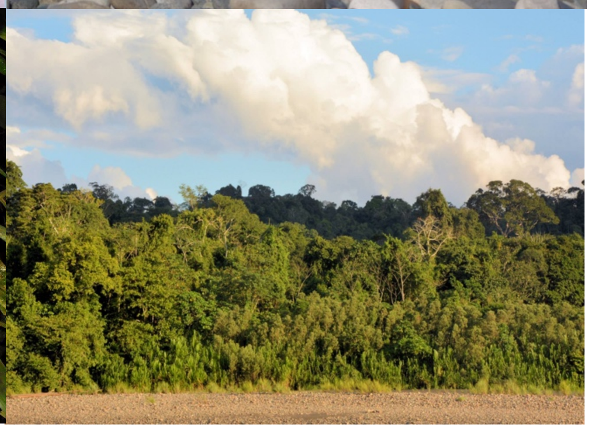
University of Glasgow Peru
Expedition Report 2015





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Manu Biosphere Reserve

The Manu Biosphere Reserve is a beautiful area rich in biodiversity, and this region provides a unique opportunity to study the effects of forest regeneration along the river networks. The reserve combines areas of strict protection with areas that have, in the past, suffered destruction from development and both legal and illegal logging but are now covered by regenerating forest. There are 3 different human disturbance histories; completely cleared regenerating, partially cleared regenerating and selectively logged regenerating forest [1].

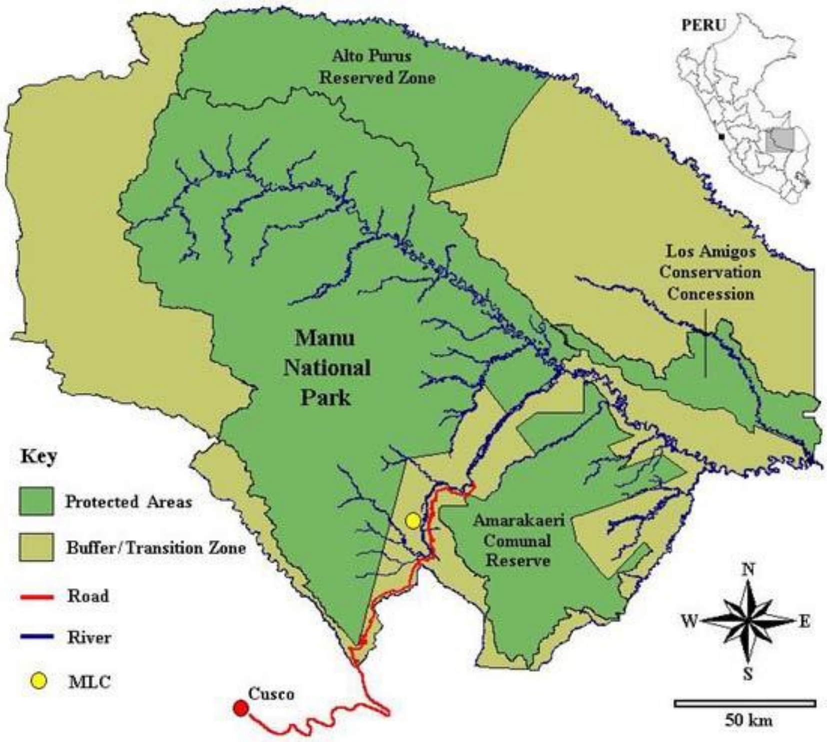

Figure 1: Map of Manu national park. The expedition field site marked in yellow [2]

The Manu Biosphere Reserve covers an area of the Amazon rainforest in South-Eastern Peru approximately 20,000 square kilometres. Although the city of Cusco is only 70km away, the lack of access routes gives the reserve a high level of remoteness and aids in its protection [3]. Currently documented in the area over 800 species of birds, over 1300 butterfly species, 200 mammal species and plant diversity is estimated between 2000-5000 species [4]. In addition, over 77 species of amphibians have been recorded [5]. The range of ecosystems in Manu covers cloud forests, lowland rain forests, Andean grasslands and swamps. The Expedition's research will be focused in lowland tropical forest, home to some of the richest biodiversity in the world.

The Manu Learning Centre

The Manu Learning Centre (MLC) is a research centre established by the CREES foundation. It is located in the Manu Biosphere Reserve in South Eastern Peru along the Madre de Dios River. The MLC is within the buffer zone of Manu National Park (the largest protected area in the biosphere reserve) and is about 10km from the heart of the reserve.

The MLC is situated in a 650 hectare privately owned protected area called the Fundo Mascoitania (Figure. 1). The area was largely cleared by logging and for agriculture in the 1960s- 1980s and then abandoned. The forest has since been left to regenerate and in 2003 the area was bought by CREES which has provided strict protection from hunting and further destructive human impacts. This protection makes the MLC an ideal site for investigating the potential conservation value of regenerating tropical forest and the effects of varying degrees of deforestation history on carbon output.

One of the main aims was to investigate the effect of human communities and the extent of their influence on the local diversity of birds, butterflies, leaf-cutter ants, mammals, amphibians and on soil quality. A comparison of biodiversity along areas of disturbed and undisturbed forest ranging in distance will further our previous knowledge on wildlife present within the MLC, allowing us to more accurately determine the impact of anthropogenic activity in this particular area.

The MLC provides researchers, scientists and volunteers with a location where they can experience the rainforest and conduct research. Ample space and facilities allow scientists to carry out simple analysis of their results, enabled by an electricity supply in the form of solar panels and a 1kw generator. Internet access is provided by a satellite internet connection and researchers can be provided access when the generator is turned on. There is also a museum containing specimens and plaster casts of tracks from animals found in the area as well as identification guides on the local flora and fauna.

In addition to the English name of Conservation, Research and Environmental Education towards Sustainability, CREES has a meaning to Peruvians as crees, translates as ‘believe’. The aims of the foundation are "to bring economic, social and environmental harmony to the Manu region." [6]. To achieve its goals, the MLC provides education for local and indigenous communities and aids in increasing their awareness of the important environment around them. The MLC also assists in the development of sustainable alternatives for energy production and other environmental interactions as well as encouraging volunteers from around the world to participate in on-going projects within the MLC. This unique approach allows the

MLC to educate a huge variety of people on the life in Amazon and various aspects of conservation and rainforest ecology.

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Results

Can Humans and leafcutter ants coexist in a human-modified rainforest environment?

Introduction

Ants have been described as one of the most successful terrestrial organisms on the planet. Their abundance and impact on the environment can be gauged by their biomass alone. Ants, on average, make up between 15 and 20% of the terrestrial animal biomass. This dominance over the terrestrial environment can increase even further in tropical climates. In such regions they can account for more than 25% of the terrestrial animal biomass (Schultz 2000). Ants have been traced back as far as the mid-Cretaceous, although some research suggests that they arose before this period. This research suggests that the family Formicidae originally appeared in the Jurassic period, but the highly diversified forms of ants only began to appear in the late Cretaceous period (Moreau, Bell et al. 2006).

Study and Project Aims

This study took place in the Madre de Dios region of the Peruvian Amazon. The Manu national park in this region is an area that of particular scientific interest for its high levels of biodiversity (Wilson and Sandoval 1996). The number of ant species alone in

Peru is over 350. Several leafcutter ant species are found in the Peruvian Amazon, two of which were studied in this project: *Atta cephalotes* and *Acromyrmex aspersus*. Along with research, the region is also used for eco-tourism purposes. As a result the park provides an excellent environment for studying the effects of eco-tourism disturbances on high-biodiversity rainforests.

The aim of this study was to investigate the extent to which humans and leafcutter ants can coexist in a human-modified rainforest environment. Several leafcutter ant colonies in areas of varying levels of human disturbance would be observed in the Madre de Dios region of the Peruvian Amazon Rainforest. The study focused on the foraging behaviour of the ants. Foraging columns were to be mapped and foraging rate was recorded over a period of four weeks. It was hypothesized that leafcutter ants would be able to coexist with humans as leafcutter ants have been found to be abundant in secondary forest. Another reason for this hypothesis was that humans would be more likely to disturb animals that might prey on leafcutter ant colonies and human disturbance could allow the foraging columns to access vegetation that had not previously been foraged. It was also hypothesized, however, that the species diversity of leafcutter ants may be reduced in areas of high human disturbance.

Methods

The time was recorded at the start of each foraging rate recording using a stopwatch. The colony and trail numbers were recorded for each observation. These numbers were recorded on the global positioning system, which could be checked to ensure that the correct colony and trail identification numbers were recorded each time. The point on the trail at which the foraging rate was recorded was determined using the global positioning system.

Each recording was made at a point along the foraging trail relative to the colony's coordinates. The distance from the colony was recorded using the global positioning system device. Foraging rates were recorded approximately every 10 meters along each foraging trail. The Global Positioning System was used to measure the 10-meter intervals. A specific point on the trail was chosen, starting at one end of the trail. One observer counted the number of ants that passed this point moving in the direction of the colony. Each observation lasted 2 minutes. A second observer used a stopwatch to time the 2-minute period. The Global Positioning System was then used to track distance as the observers followed the trail for 10 meters. This process was repeated along the trail until foraging rates had been recorded along the full length of the trail.

A note of the weather conditions was made at the time of each observation. It was also noted if there had been rain recently. This was because there had been a marked lack of activity after periods of heavy rain.

The destination of each foraging trail was recorded. The End Distance was a measure of how far the trail travelled from the colony. This was measured using the Global Positioning System. The End Point was also observed. This noted the foraging destination of the trail. This could be a tree, leaf litter or another substrate. In some cases the trail become impossible to follow, either due to safety or an inability to visibly track the foraging route. In this case, the furthest point on the trail was recorded with the Global Positioning System and the End Point was noted as inaccessible.

The observer who recorded each measurement marked his or her own initials. This was to prevent confusion if some observations were missing. In addition to these observations, notes could be made on the data sheet. This could be used to explain any lack of data or unusual circumstances. It was also noted if the foraging rate was recorded on a pathway. The Data Sheets were used to record observations four times a week. The nocturnally active ants were observed two times and the diurnally active ants were observed twice also. This means that each colony was observed twice each week.

Results

The data was analysed in R studio, producing the following statistical analyses and figures using ANOVA general linear models.

Foraging Rates

Figure 1

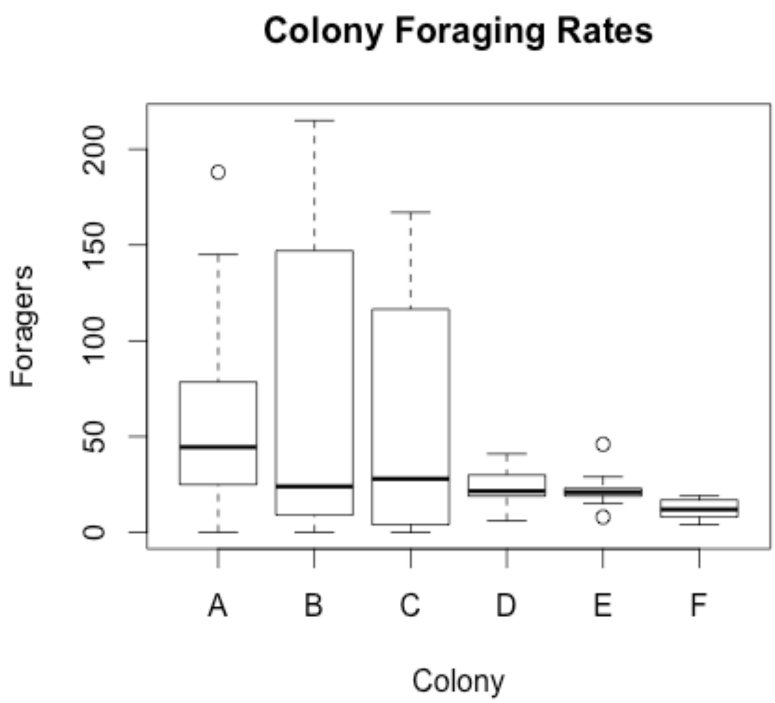

Figure 1 shows the foraging rates at each Colony. Colonies A, B and C show much wider ranges of foraging rate. They also display much larger maximums than colonies D, E and F, the maximum of which do not exceed one quarter of colony B’s maximum rate. The thick black bars represent the mean foraging rate of each colony.

Table 1, below is an analysis of variance table for a general linear model of foraging rate versus colony. This found a significant relationship between colony and foraging rate ($F_{1,5} = 4.446$, $P = 0.0007953$).

Table 1

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Analysis of Variance Table

Response: Foraging.rate
          Df Sum Sq Mean Sq F value    Pr(>F)
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Figure 2: *Atta cephalotes* observed during survey

Foraging Area and Colony Size

The data recorded for maximum trail distance was used to estimate the maximum potential foraging area. The trail distance was used as a radius measurement, creating an estimated, circular foraging area surrounding the colony nest. Table 2 shows the Mean Trail distances and Estimated foraging area for each colony.

Table 2

Colony	Species	Mean Trail Distance (M)	Estimated Foraging Area (M^2)
A	Atta	70.5	15614.5
B	Atta	44.725	6284.2
C	Atta	63.15	12528.4
D	Acromyrmex	41.275	5352.1

E	Acromyrmex	23.25	1698.2
F	Acromyrmex	23.325	1709.2

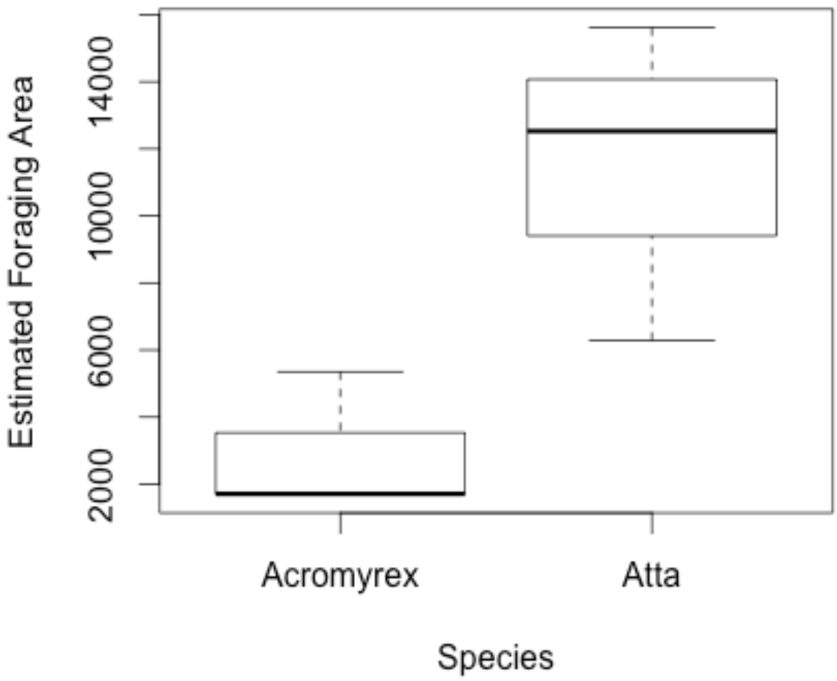

Figure 3

Figure 3 shows the relationship between Species and Estimated Foraging Area measured in m². *Atta* were shown to have a much larger potential foraging areas. The smallest *Atta cephalotes* foraging areas were larger than the largest *Acromyrmex aspersus* foraging areas.

Discussion

Limitations of the Study

The study was limited to observing six leaf cutter ant colonies in detail. Problems initially locating ants were likely due to the lack of diurnal activity. The initial colony searches took place during the daytime and the study had intended to only observe the daytime activity. When it became clear that this would not be possible, the study was altered so that nocturnal activity could also be observed. In future studies in this area it would be recommended to revisit previously discovered colony nests in order to increase the time used to make new observations. Observing the nocturnal species, Acromyrmex asperses, posed more challenges. It was difficult to determine when the ants would be at their most active and some times of night would be too impractical to make observations regularly. As the only species of leafcutter ant found in the Mirador trail area was *Acromyrmex aspersus*, it was difficult to gauge the effect of human disturbance on each species. In order to study this more effectively, ant colonies of various species would need to be observed in areas of varying human disturbance.

A physical limitation was how far the foraging columns could be followed. Leafcutter ants will continue to travel through the forest in the arboreal canopy (Hölldobler and Wilson 1990). Due to safety reasons, it was not possible to follow the foraging column into the canopy. Further research, with the correct equipment, could reveal how much further leafcutters travel once they reach the canopy. It is possible that leafcutters travel great distances in the canopy as they can navigate more efficiently in sunlight (Banks and Srygley 2003).

Foraging Area and Colony Size

The foraging areas of *Acromyrmex aspersus* and *Atta cephalotes* were significantly different. The potential foraging area of *Atta cephalotes* was consistently substantially larger than that of *Acromyrmex aspersus*. This relationship continued in colony size. The potential foraging area was likely larger to support a much larger colony in the *Atta cephalotes*. Although, this may be the reason why *Atta cephalotes* was not found in areas of high human disturbance. *Acromyrmex aspersus*' ability to maintain a successful colony despite lower foraging rates and a smaller foraging area could allow it to coexist to a greater degree with humans in a secondary rainforest environment.

Species Biodiversity

One of the most glaring observations made in this study was the lack of any *Atta cephalotes* colonies found in the Mirador trail area. This area is frequently used for eco-tourism purposes. It is likely that human disturbance resulted in the loss of ant diversity. Human impact has been credited with causing a decline in ant diversity in previous studies (Folgarait 1998). Although the disturbance may lead to a decrease in biodiversity, it may also promote coexistence between humans and the remaining ant species. Human disturbance can remove species that compete with the *Acromyrmex aspersus* species, allowing them to take advantage of the increasingly abundant food sources and habitable zones (Denslow 1996). The presence of a single species of leafcutter ant may not be beneficial to the surrounding environment. Different species will alter the soil composition to varying degrees and the chemical composition will change depending on the species of leafcutter ants that are present (McGinley, Dhillion et al. 1994). The result of a single species of leafcutter dominating an area will result in a lack of variation in soil composition. This may lead to a limited biodiversity of vegetation as only certain plants will be able to grow in soil of such a chemical composition (Folgarait 1998). The full effect of reducing ant biodiversity on surrounding soil composition is difficult to quantify as it is still unknown to what extent leafcutter ants alter nutrient cycling and rate of organic decomposition, as well as their effect on pests and diseases found in the soil (Folgarait 1998).

Atta cephalotes were only observed in regions of lower human disturbance. The foraging behaviour of this species may explain their absences in areas more prone to human disturbance. *Atta cephalotes* were frequently observed foraging from vegetation over 50m away from the colony nest. Longer foraging trails increase the chances of human disturbance impacting the foraging column. If *Atta cephalotes* require a larger undisturbed foraging area, it would explain the lack of *Atta* colonies in the areas of increased human activity. Previous studies have shown that *Atta cephalotes* will consistently forage up to distances of 31.2m on a routine basis, but sometimes they are found to forage up to 78m from the column, although the foraging effort is significantly reduced (Cherrett 1968). Only nocturnal activity was observed on the Mirador trail. This may be another reason why *Atta cephalotes* were not found in the areas of increased human disturbance. Whilst *Atta cephalotes* have been observed to be prolific nocturnal foragers, they also forage during the day and the extra hours of foraging may be necessary in order to gather the requisite volume of vegetation to sustain the colony nest (Cherrett 1968). If daytime human disturbance has prevented diurnal foraging it would explain the lack of successfully established *Atta cephalotes* colony nests in the areas of increased human disturbance. Colony nests found in the Mirador trail were consistently smaller than those found in areas of lower human disturbance. This could support the idea that diurnal foraging is necessary to support a large *Atta cephalotes* colony nest. Human disturbance is not likely to be the only factor affecting leafcutter ant species diversity. Previous studies have shown that the most important factors in determining ant species diversity are climate based, such as annual precipitation and temperature variations; other factors include the structural complexity of the environment (Alejandro Gustavo Farji and Ruggiero 1994).

Wider Implications

Leafcutter ants are recognised as an important keystone species in large parts of the neotropics (Vasconcelos and Cherrett 1995). For this reason among others they are regarded as a good indicator species of the surrounding environment (Hölldobler and Wilson 1990). It has been suggested that leafcutter ants could be used to restore damaged areas of rainforest. This is because they are easily introduced to recovering forests and they have been found to promote the invasion of alien plant species (Farji-Brener, Lescano et al. 2010).

Conclusions

This study highlighted how, despite sharing their general life strategy and colony structure, the differences between leafcutter ant species can be very significant. These differences can allow them to survive in different areas of human-modified rainforest. This study appeared to show that *Acromyrmex aspersus* could coexist to a greater degree, with humans. Although, more concentrated study would be required to ensure that human disturbance is the leading cause of *Acromyrmex aspersus*' success. Whilst coexistence may be beneficial to certain species of leafcutters, it is likely indicative of a less biologically diverse forest environment. For this reason, coexistence may not be a positive force on recovering or human-modified environment. However it is another reason for leafcutter ants to be studied further and used as an indicator species. They not only modify their own environment, but also change the structure of the forest around them.

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Soil and Environmental Analysis

Abstract

Investigating the impact of human disturbance on the soil characteristics of national park path networks requires knowledge and understanding of both the human and physical environments. Research ranges from looking at the uses and users of the path, to investigating characteristics such as the pH and infiltration rate of the path soils. Globally, national parks are found over a wide range of human and physical landscapes meaning that the 'one-rule-fits all' application does not apply when investigating the path networks of such protected areas. The study area investigated here was chosen due to it being a newly formed path network which experiences a low level of footfall along its paths. At each sample site water infiltration rate, pH, leaf litter depth and vegetation cover were recorded. General site differences were noted and as were observations of human use. Analysing the different factors gave a deeper understanding of how a low level of human disturbance can affect a path network. The different factors were then plotted against each other to determine the strength of the relationship producing graphs for each site, with conclusions drawn from the results. It was concluded that a low level of human disturbance does have an overall effect on the soil characteristics of the path network in the study area.

Introduction

Globally, in National Parks, paths and tracks allow access to areas of public interest. (McNealy et al 1985)Paths usually play one of three key roles - to provide access, to support recreational activities and to protect park resources by concentrating access to specific areas. Path networks are usually a vital necessity ensuring access for the wider public. They are also essential in fulfilling the educational role which is the purpose of many parks. However, the increase in intensity of use of these path networks has created the wider issues of changes to soil characteristics and an increase in soil erosion along the tracked areas of the park. (Calais et al 1986)The Manu national park in which the study area was located is frequently used by tourists 'experiencing' the amazon and scientists exploring the area. Path network degradation in national parks has attracted research attention for decades. Since the rise in popularity of the countryside the literature has focused on the conflict of human disturbance on the natural habitats of the national parks, documenting changes in the environment in response to differing levels of intensity in human disturbance. From the research done for this study it is apparent that much of the previous academic studies have focused on in depth analysis of path incision, muddiness and widening from high intensity usage (Cole et al 1990).However, the focus of this particular study is not the destruction of the soil from the intense use of the paths by the public but how low level disturbance for scientific purposes has an effect on the pristine environment of the Manu Biosphere reserve (the study area)and whether this has an impact on the soil characteristics of the path network that was present in our study area.

Aims

The overall aim of this study was to investigate whether human disturbance has had an effect on the soil characteristics of the low use newly implemented pathways of the Shintuya region of the Manu Biosphere Reserve in Peru.

A set of sub aims were established to help achieve the overall aim of the study, these were as follows

To map the path network of the Shintuya region of the Manu Biosphere Reserve

To determine if pH, Infiltration, leaf litter and vegetation coverage changes along the path network with changing footfall intensities

To compare the inter relationships between the variables of pH, Infiltration, leaf litter and vegetation coverage and or whether they affect each other

Methodology

After examining the literature surrounding the human disturbance upon pathways in national parks a number of techniques emerged as the best suited to this specific type of physical fieldwork.

The path network was first mapped then split into sub-paths A,B,C,D,E and M. This allowed sufficient analysis to be carried out to acquire robust results.

Infiltration Rate

The infiltration rate of the soil was gathered as it is a good indicator of the compactness of the soil on the path indicating a high rate of footfall.(Willard et al 1970) It was hypothesised, after reading the literature, that there would be a longer infiltration rate if there was shallower depth of leaf litter. This was assumed to be due to the removal of leaf litter from trampling would result in compaction of the soil that makes up the network. Infiltration rates were measured at each sample point using a single ring infiltrator. The use of a single ring infiltrator allowed the uninterrupted determination of the rate of flow of two hundred millimetres of water. Infiltration is the downwards entry of water into the soil and the infiltration rate is the velocity at which it occurs. The infiltration rate is a great indicator of the health of the soil as it educates the investigator on the movement of water within the soil cell which is essential for aerobic respiration of the soil. If the situation occurs where the soil is to compact to absorb the water or has already met its peak absorption capacity then the water moves downslope as runoff and sheet erosion can occur. Throughout the literature it was evident that infiltration rates were very sensitive to change in soil use and management. It was deemed not desirable for a soil to have a long infiltration rate as this indicates compaction of the soil. The type, texture and structure of the soil were all listed as properties that control how fast the soil responds to change. The rainforest is a highly active and mobile environment meaning its soils are very susceptible to change and so infiltration rate was an ideal technique to implement in the study area.

Measuring the infiltration rate using a single ring infiltrator allowed the guarantee that it was the downwards motion of water into the soil that was being measured and not the lateral diffusion of the liquid. This is essential for precision when measuring infiltration rate and allows a valid comparison of sample sites to be made. A stop watch was used to time the infiltration rate and this was subject to operational error.

From previous work on the impacts of trampling on natural ecosystems in the st Clair national park, (Calais et al 1986)it was clear that taking a measurement of pH would be valuable for the researching the effects of human disturbance on the path network. PH is directly affected by human disturbance and very sensitive to change. This is because pH is very sensitive to changes in the decomposing organic matter that contributes to the ao layer of the soil. The decomposing organic matter is directly influenced by trampling and the type of vegetation that can withstand human disturbance.

PH is a measure of acidity and in this study was measured using a pH meter. Values below seven are considered acidic and values above seven alkaline. Most plants can tolerate a wide pH range in solution culture such as acid rain. However they cannot tolerate a wide range in the acidity of the soil, hence a lowering of pH on the path network can be detrimental to the surrounding vegetation. The lack of tolerance to an acidic soil by plants is due to the fact that soil pH influences the availability and uptake of plant nutrients and the solubility of minerals into the soil. The bacterial activity of nitrogen fixing bacteria which are responsible for the release of nitrogen from organic material back into the soil is highly sensitive to a change in pH. Acidic conditions in the soil are usually associated with leaching hence a slightly acidic soil was thought to occur in our study area anyway. Although pH is not an indication of fertility it does affect the availability of fertiliser nutrients and thus can limit the growth of vegetation. It was hypothesised that there would be a lower pH in areas where the leaf litter depth was lowest and infiltration rate greatest. It was also hypothesised that a lower pH would lead to a lower percentage cover of both shrub and herb layer.

To measure the pH of the soil a ten gram sample of the soil was taken at every sample point along the path network. This ten gram sample was then put in solution and a pH reading taken, using a pH meter. The pH meter was calibrated regularly during fieldwork using a predefined pH solution, this worked as a control. The pH meter works by measuring the hydrogen-ion activity of the soil solution, thus allowing the acidity or alkalinity to be measured.

Vegetation sampling

All the plant life existing at a specific time or place is termed vegetation the type of vegetation growing in a specific location is directly related to factors such as climate, topography, soil condition, natural and human disturbance. The study of vegetation in a physical environments brings in aspects of both space and time, deepening's ones understanding of the form and function of the vegetation. With specific reference to this study the effects human disturbance has on the vegetation that grows in the spaces which have been used as part of the path network is of great interest.

Vegetation is important to the environment and essential part of all rainforest ecosystems. It is also sensitive to change which makes it a brilliant indicator for human disturbance thus its importance as part of this study. Quantifying vegetation can be done by examining the past or present species composition of a vegetation type. In this study it was the present vegetation that was concentrated on. The vegetation sampling took place using a quadrat as the main focus for the sampling. It was a one meter squared quadrat that was used and it was deemed the most efficient way of surveying in the literature. In terms of time management surveying all the vegetation present in our study area without the use of a quadrat would have been an endless task, the literature also stated that using quadrats produces a high resolution data on species richness and density in a given area which is what was required for this study (Gillespie T 2010).

As part of the vegetation sampling, a physiognomy study of the dominant vegetation groups was undertaken to calculate the percentage cover of the sample areas. The dominant vegetation was classified into two groups to allow a more accurate percentage cover to be calculated. These were shrub layer and herb layer. Shrub layer included anything that was multi stemmed but less than two meters tall and the herb layer referred to anything that was a small herbaceous plant such as grasses and wildflowers. Herbaceous communities are usually permanent grass based communities so a lack of these can show a high rate of human disturbance. Canopy cover and mid canopy cover was also analysed this was done via using an observational grid and was calculated in percentage cover. Canopy cover was measured as this would have a knock on effect on the volume of rainfall that will be able to enter downwards into the soil. The three largest trees within the one metre squared quadrat were sampled and their diameter at breast height sampled, this was measured using a measuring tape. The diameter was measured at breast height to ensure consistency over time. The larger the diameter at breast height the more carbon the tree can store which is essential to the rainforest ecosystem, Human disturbance in the form of selective logging can interfere with the carbon sink potential of the rainforest. Although this is not directly caused by scientists to create pathways for the scientists to carry out their research selective logging practices were implemented. Also now having this path network means it is easier for the community to have access to the trees and thus it maybe that higher rates of selective logging occur

Leaf litter depth was measured as in previous studies carried out in Yosemite national park leaf litter coverage and depth had been decreased by human trampling of the pathway. Measuring leaf litter depth was essential when measuring Ph. as decomposing leaf litter is acidic and will have a knock on effect on the ph. of the ao layer of the soil. The decomposition of leaf litter is of great importance to the health of the soil as the breakdown of the organic matter by small invertebrates and bacteria replenishes the nutrients in the soil. A quadrat was implemented when measuring leaf litter depth to create a grid in which the samples of leaf litter were measured. Leaf litter depth was measured using a ruler and was measured from the ground to the point at which the top leaf of the leaf litter hit the ruler. Four random samples were taken in each square of the quadrat and then an average taken for the whole area. Taking random samples insured that the samples were not biased and accurately represented the area. Leaf litter is directly affected by human disturbance and this was evident in the literature but also in the field site as many scientists had cleared the areas in which they had their equipment hence low leaf litter depth, continuous trampling of the paths has also not allowed leaf litter to settle and thus it cannot decay.

Results

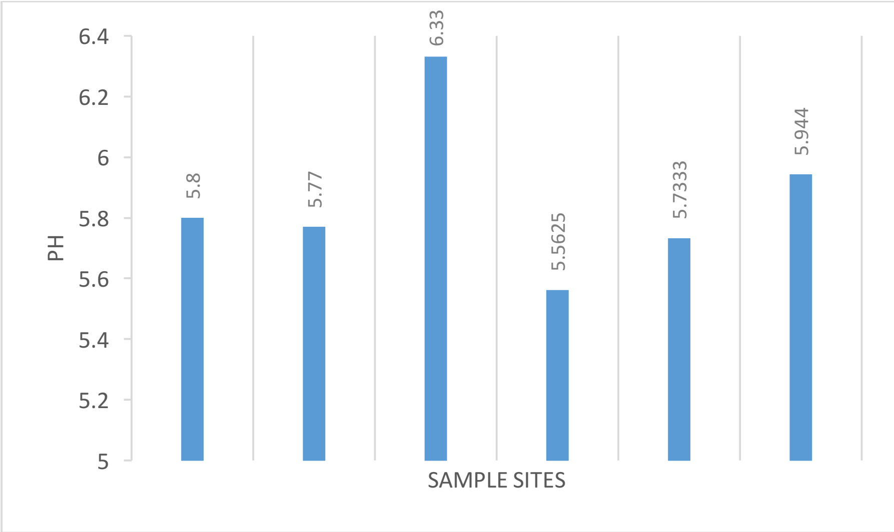
Infiltration rates throughout the park

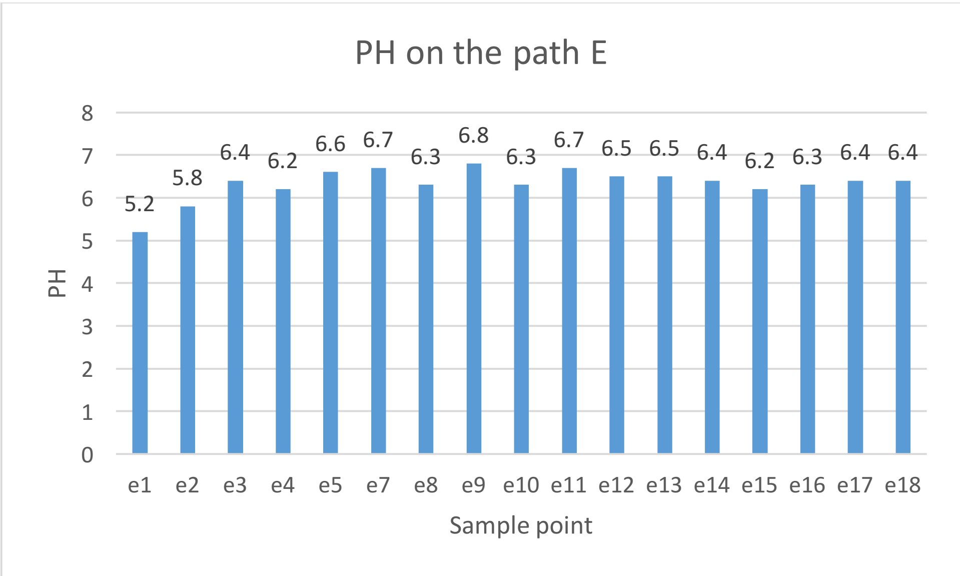
Infiltration rate values vary throughout the path network. However the slower infiltratation rates occur more frequently in the areas where there was an observed higher footfall, with more scientific work being carried out in these areas of the path. For example path B shows a higher frequency of slow infiltration rates than any of the other paths in the area. This area of the path network was used more frequently for daily bird and butterfly surveying work than the other areas of the network of paths.In Chappell et al's work in 1971 he claims that the percentage water content of the soil may decrease inareas where it is wetter this could be as a result of compaction, and thus produce a slower infiltration rate. With compaction the pore sizes of the soil shrink this results in high bulk densities of the soil and hence a reduction in overall air diffusion and mass flow making it harder for the water to infiltrate down through the layers of soil. This can be seen when examining results obtained in this paper the average infiltration rate for path e was 39.23s and the infitration rate for path d was 30.11s. These parts of the path network recived a simlar volume of human traffic but path e route was through a damp swamp meaning many of the samples points had a higher degree of saturation from those at path.

PH RATES ALONG THE PATH

The optimum pH is essential to the productivity of the soil. The measurement of pH is highly sensitive to its surroundings thus the results differ along the pathway network. The pH results were always within the range of 4.5-6.8, with the the average pH of the soil along the pathways being 5.9. A pH of 5.9 corresponds to a mildly acidic soil which is what was expected from rainforest soils, acidic soil contributes to 63% of the land in the humid tropics,(Motavali et al 1995). The pH of the soil is more acidic when there is a greater depth of leaf litter, this is because the decaying leaf litter attributes to the acidity of the soil. In areas of high footfall the results show a more alkaline pH due to the lack of leaf litter available to decay naturally on the pathway. Path E network had a high footfall rate as this part of the path allowed access to all other areas of the network. Path E had a pH of 6.3 this was higher than average for the path network.

The figure below shows the average pH of all the pathways in the study area





graph 3

Figure three shows that there are a number of discrepancies within path E itself, this could be due to a number of reasons. Firstly trampling is not going to be of the same intensity throughout the path, the areas where for instance on path E camera and butterfly traps were located would result in higher rates of trampling and thus more alkaline pH results which is consistent with the result that were collected. Butterfly traps were located at sample point E3,E7,E11and E17 and figure three confirms that all of these sample points have a pH higher than average for the path. Secondly the pH is not just dependant on the intensity of trampling an area of soil receives, but that the pH is also dependant on relief and rainfall. Path E was located on a hill slope which would encourage leaching of minerals to occur lowering ph. The pH meter that was used to collect the data at the sample points is subject to error with it sometime hovering between two points so being at the operators discrepancy as to which pH to ‘choose’. The same pH meter was used at every sample point ensuring a level of consistency throughout the results.

Leaf litter depth along the path network

Litter depth fluctuates along the path network as shown in figure four. Path C has the deepest recorded leaf litter depth for the path network in the study area. This path was the furthest removed from human communities, be that scientific or native. It was also the most overgrown of the entire path network which gave the impression of infrequent use and that there was little upkeep to the path. The lack of human disturbance on path c gave a higher leaf litter depth as trampling causes a decrease in overall depth. This can be seen by comparing the average depths of both C (a less frequently used path) and E (a more frequently used path). Path C has an average leaf litter depth of 57 mm whereas path E has a leaf litter depth of 28mm. Path E was the path most used for accessing the other paths. Path E was also located along one of the flat ridges located in the study area. This area had been more extensively logged this is shown in the analysis of the results from the canopy cover survey.

Percentage Herb and Shrub cover along the path network

The herb and shrub layers are great indicators of the negative effects of human disturbance. Rainforest environments are world renowned for their diversity and species richness with the herb and shrub layers being generally dense and heterogeneous in nature. The herb and shrub layers are very sensitive to changes in soil characteristics and to disturbance to their surrounding ecosystem. As stated in the literature review, the resilience of a plant to human disturbance is species specific. This means only a broad general conclusion of the effect of human disturbance can be drawn from analysing the percentage cover of the herb and shrub layers. However the results acquired are still highly valuable to the study.

The shrub and herb layer percentage cover always falls within 30-75% for the entire path network. Obviously this is a large range and on each path there is a differing percentage cover. Path B once again shows the lowest percentage cover of herb and shrub layers, this path, as stated previously was the path with the highest observed human disturbance. Path B has an average cover of around 30-45%. Path M had the highest percentage cover of herb and shrub layers of around 60-75% this path was at the furthest reaches of the study area and furthest from any human community hence had the least human disturbance.

Conclusion

Drawing upon the initial aims that were set out, the investigation into the human disturbance of the path network at shintuya succeeded in confirming many of the preconceived ideas, however for some variables interacted unexpectedly with each other suggesting further analysis of these variables are needed to fully understand there interactions as part of the wider ecosystem.

It was expected that a larger leaf litter depth would lead to a longer infiltration rate. However a weak relationship was observed between the leaf litter and infiltration rate and further studies with more data points would be needed to strengthen this relationship. There is evidence to suggest that a greater leaf litter depth would make the infiltration rate slower as with greater depth there would be less potential percolation of water. There was wide variation in the data collected for this relationship, meaning that the collection of more data may have strengthened the relationship.

A higher coverage of the herb layer was expected to lead to a more acidic pH. On examination of these two variables a low level of correlation was found. This was unexpected as when examining the relationship between pH and shrub layer a high level of correlation occurred and thus it was presumed that a similar level of correlation would occur between pH and herb layer. Again there was large variation in the data collected the various sample sites so with more sample sights the significance of the lack of a relationship would be increased.

It is evident that human disturbance influences much of the soil characteristics of the path network in the shintuya region of the manu biosphere reserve. The intensity of footfall seemed to determine how much the soils characteristics were influenced, this was as expected. Networks of paths are essential to encouraging the use of our national parks, allowing the public to be educated by, and seek enjoyment from their surroundings I feel is essential for the happiness of human populations. Hence path network management should be at the forefront of government agendas as the preservation of these areas of outstanding beauty of utmost importance.

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Can Neotropical Rainforest Mammals Successfully Coexist with Human Use?

Introduction

Much of the Peruvian Amazon, including the Madre de Dios, is under continually increasing pressure from human population expansion and so, unfortunately, still faces threats to its biodiversity (Bennett et al. 2001). For example, even in specifically protected areas such as the Manu Reserve where it is technically illegal, harmful practices like hunting are still very common and it is rare to come across even small mammal populations which have not been targeted at all (Bennett et al. 2001). Illegal logging is also still extremely widespread throughout the Peruvian Amazon, despite attempts to regulate it (Finer et al. 2014), with the vast majority of timber from Peru being obtained illegally and unsustainably (Sears & Pinedo-Vasquez 2011). Such unsustainable practices as selective logging pose serious threats to the great diversity of already vulnerable wildlife in the Peruvian Amazon (Juvonen & Tello Fernandez 2004). Within Manu Biosphere Reserve and the Madre de Dios, however, by far the major form of human activity which occurs is tourism (Patterson et al. 2006). Over the last 20 years, ecotourism sites have become increasingly abundant across many regions of the Peruvian Amazon, especially in areas surrounding rivers such as the Rio Alto Madre de Dios and other headwaters in the Madre de Dios region (Salvador et al. 2011). A successful example is the Cuzco-Amazónico Lodge, which opened on the Madre de Dios River in 1976 and was welcoming as many as 3000 tourists a year by 1990 (Yu et al. 1997).

This project focusses on a similar, but less well-known ecotourism site also situated on the Rio Alto Madre de Dios, near the community of Shintuya. The main aims of the study were: to assess the diversity and richness of medium to large-sized mammal species in the area (primarily terrestrial species), determine the level and types of anthropogenic use of the forest both by tourists and local people and, finally, assess the effects of this human use on the presence and activity of mammal species across the different forest trails. The study focuses on medium and large-sized mammals, rather than other animal groups or small mammals, because they are much easier to detect, identify and record in the field than other groups such as birds or amphibians, and they are also thought to be the most susceptible to the impacts resulting from human activity (George & Crooks 2006). The specific questions and predictions investigated are as follows:

1 What are the major forms of human activity occurring in Aguas Calientes and how intense are these activities?

2 It is predicted that the richness and diversity of mammal species will increase with distance along the trails from main site of the lodge.

3 Mammal abundance and activity should be lower at times when, and in areas where, human activity is high.

Materials and Methods

Visual Surveys

On-foot surveys were carried out over a period of six weeks during the expedition, with surveys being carried out five days a week. Eight transects were set up over two days with four being set up on each day (the same transects used for bird surveys). All transects were set up to be 500m in length and were marked using duct tape at each 50m interval. The start and end points of each transect were marked with red ribbon so that they were easily visible and separate transects were set 100m apart. Mammal surveys were combined with bird surveys so that the same transects did not have to be walked separately for each. Surveys began at 6am each morning with two transects being covered each time. It was aimed to spend at least 30-40 minutes on each transect so that surveys would be completed within two hours. Each transect was carried out six times, meaning 48 transects were walked in total. Transects were walked as slowly and quietly as possible, in order to minimise disturbance to wildlife and so that any calls or movements would be heard easily. Any mammal encounters along transects – whether audio, visual or tracks – were recorded along with the time, date, weather, distance along transect, group size of mammal and the height they were observed at. Outwith the time of the surveys, incidental mammal sightings were also recorded using a similar process, again recording the time, date, weather, location, group size and height. Once back at camp after surveys were complete, Neotropical Rainforest Mammals (Emmons & Feer 1997) was used to identify species that had been recorded.

Camera Traps

In addition to physical encounters, mammals were also recorded using Bushnell camera traps which were set up at 16 individual locations across the different forest trails. Seven of these camera traps were provided and set up by CREES in the last week of April prior to the expedition, so that data was able to collected over a longer period of 3-and-a-half months, and the remaining 9 were set up in the last week of June. All traps were left up until the 31st of July. The cameras were set up in relatively clear areas along the forest trails with little vegetation to obstruct the view, and set at suitable heights (roughly 50cm off the ground) for capturing medium-large-sized mammals walking along the trails. A stick was often used to prop the camera at a suitable angle.

Analyses

Following data collection, statistical analyses were carried out using only the camera trap data, as this provided the most extensive and accurate records of both mammal and human activity in comparison to the relatively small dataset acquired from the on-foot surveys. Both camera trap data and survey data were included in the final species list, however. General Linear Models were carried out for daily human and mammal activity patterns to establish any relationships present. Human and mammal activity was also examined on a monthly scale over the research period to determine any patterns between human and mammal numbers. Camera trap locations were categorised into areas of varying human disturbance and a GLM carried out to establish any relationship between the levels of human activity and the number of mammals recorded.

Results

Observed Species List

Over the course of the study, at least 31 mammal species were recorded in total, 18 of which were terrestrial. The actual number of species may be more than this, as for some individuals it was not possible to identify their exact species. In such cases, these species were grouped under more general classifications (e.g. 'Medium-Sized Armadillo' and 'Capuchin'). There were also 14 recordings in which the mammal species could not be identified at all – usually due to poor picture quality on the camera traps or the mammal being captured just as it moved out of the frame – and so these observations have simply been grouped under 'Unknown'.

Table 2 shows the full list of the 31 mammal species with their IUCN status (IUCN 2015), the number of times each species was observed and the recording method from which these observations came. Pacas were by far the most observed species having been recorded 127 times, with Brazilian tapir, red brocket deer and collared peccary being the 2nd, 3rd and 4th most observed species respectively. These species are highlighted in red in Table 2.

Table 2 - Recorded mammal species in Aguas Calientes over 6 weeks. 'Total Observations' states the total number of recordings of each species collated from all methods; CT = Camera Trap observation, V = Visual observation, T = Tracks, A = Audio

Species	Total Observations	Evidence	IUCN Category
Agouti	3	CT	Least Concern
Black Mantle Tamarin	1	V	Least Concern
Brazilian Tapir	55	CT, T	Vulnerable
Capuchin	5	CT, V	Least Concern
Capybara	2	T	Least Concern
Collared Peccary	29	CT, V	Least Concern
Common Squirrel Monkey	1	V	Least Concern
Four-Eyed Opossum	1	CT	Least Concern
Giant Armadillo	3	CT	Vulnerable
Green Acouchy	3	CT	Least Concern
Hoffman's Two-Toed Sloth	1	V	Least Concern
Jaguar	14	CT, T	Near Threatened
Jaguarundi	1	CT	Least Concern
Margay	1	CT	Near Threatened
Medium-Sized Armadillo	13	CT	Least Concern
Monk Saki Monkey	1	V	Not evaluated

Neotropical Otter	1	T	Near Threatened
Ocelot	12	CT, T	Least Concern
Paca	127	CT	Least Concern
Puma	18	CT, T	Least Concern
Rat	2		n/a
Red Brocket Deer	33	CT, T, V	Data Deficient
Red Howler Monkey	1	V	Least Concern
Saddleback Tamarin	4	V	Least Concern
Short-Eared Dog	8	CT	Near Threatened
Southern Tamandua	1	V	Least Concern
Tayra	1	V	Least Concern
Titi Monkey	3	A, V	Least Concern
Unknown	14	CT	n/a
Woolly Monkey	1	V	Vulnerable
Yucatán Squirrel	1	V	Least Concern

Figure 1: Jaguar observed on camera traps

Daily Human Activity

A total of 854 human observations were recorded on the forest trails in Aguas Calientes over the course of the study. 74% of these observations were researchers – the majority of which (92%) were the Peru expedition team for this project. Tourists comprised 22% of human observations, and other humans which were either identified as being people from the local community or were unable to be grouped into a specific category, made up only 4%.

Daily Mammal Activity

Overall, mammals were active during all hours of the day (Figure 2). Mammal numbers were highest during the evening and night through to the early hours of the morning. It was found that there was no significant relationship between overall mammal activity and the hour of the day ($F_{1,21} = 2.8$, $P = 0.108$) but a negative relationship between human activity per hour and mammal activity per hour was found to be very close to significant (Human activity: -0.03, SE = 0.01, $F_{1,21} = 4.2$, $P = 0.054$).

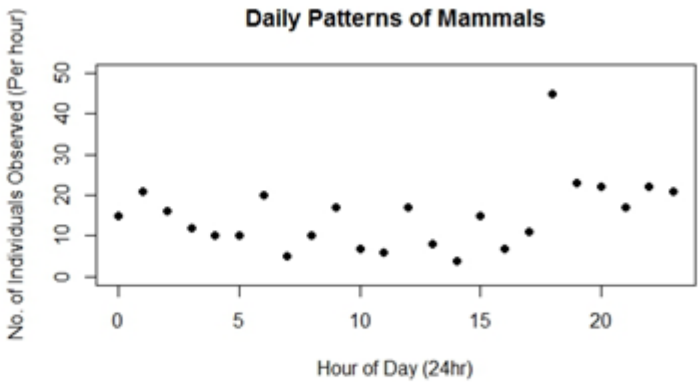
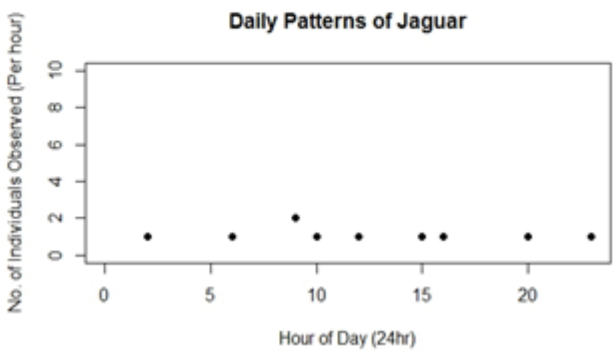
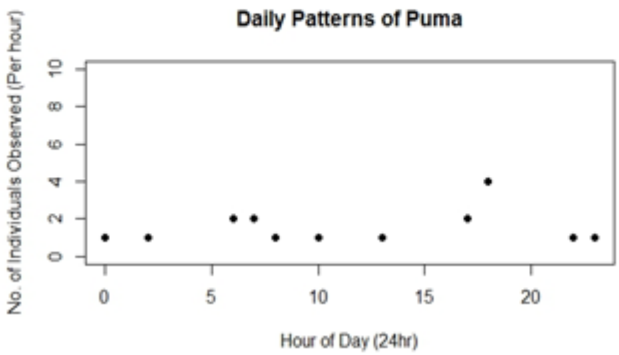
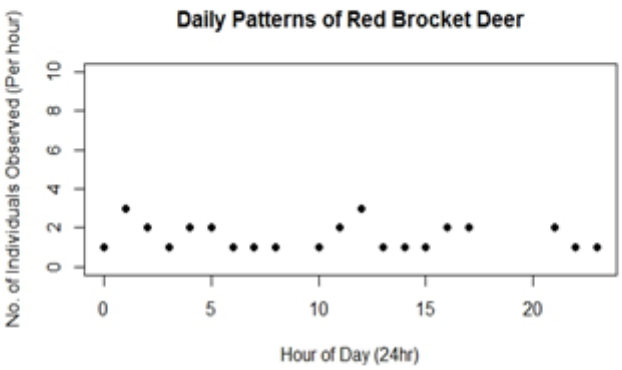


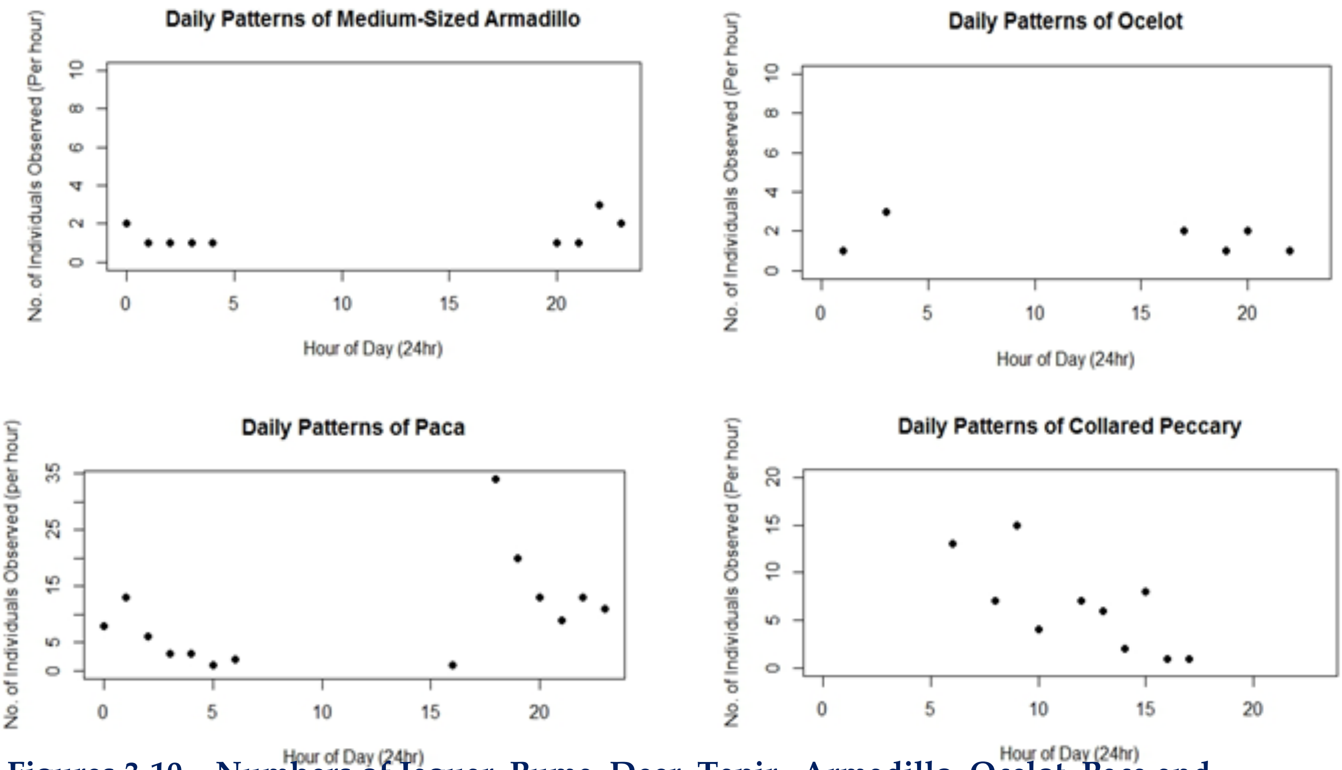
Figure 2 – Number of mammals observed (via camera traps) in Aguas Calientes during each hour of the day over 14 weeks

Daily patterns became much clearer when individual species' activity was analysed. Figures 3-10 show the individual activity patterns of certain mammal species (daily activity was plotted only for those species which were observed at least 8 times over the study).









Figures 3-10 – Numbers of Jaguar, Puma, Deer, Tapir, Armadillo, Ocelot, Paca and Peccary recorded (via camera trap) in Aguas Calientes during each hour of the day over 14 weeks

The only species which showed significant (or close to significant) relationships with human activity were the following:

- Human activity had a significant negative relationship with the activity of the Brazilian tapir (Human activity: -0.008, SE = 0.003, $F_{1,21} = 7.4$, $P = 0.013$) and medium-sized armadillo (Human activity: -0.003, SE = 0.001, $F_{1,21} = 6.7$, $P = 0.017$). When the analysis was repeated using the factors 'day' or 'night' rather than just 'hour' it was found that Brazilian tapir and armadillo activity was significantly related to whether it was night or day ($F_{1,20} = 22.5$, $P = 0.001$),($F_{1,20} = 23.9$, $P = <0.001$), therefore it is likely that the relationship with human activity here is coincidental and not, in fact, influenced by the presence of humans using the forest trails.
- Paca activity showed an almost significant positive relationship with hour of the day (Hour: 0.42, SE = 0.20, $F_{1,21} = 4.1$, $P = 0.056$) and a negative relationship with human activity (Human activity: -0.03, SE = 0.01, $F_{1,21} = 7.2$, $P = 0.014$). Again, repeated analysis found that paca activity was significantly related to whether it was night or day ($F_{1,20} = 5.1$, $P = 0.035$).

Monthly Human Activity

Figure 11 shows the number of humans recorded in Aguas Calientes each month from the second half of April through to the end of July. Human activity was found to be highest in the second half of June through to the end of July, with numbers reaching up to around 50 people per day in both these months. Mammal recordings per month are shown by Figure 12 and species numbers per month by Figure 13. Both number of mammal species and individuals did not appear to particularly reflect the pattern seen in humans. Total numbers of species recorded were roughly the same through May to July and numbers of mammal individuals recorded follows much the same pattern, remaining fairly high with only a slight dip in numbers in the second half of June. Mammal numbers increase again greatly in the first half of July while numbers of humans drop slightly, then mammal numbers decrease again slightly as human numbers go back up.

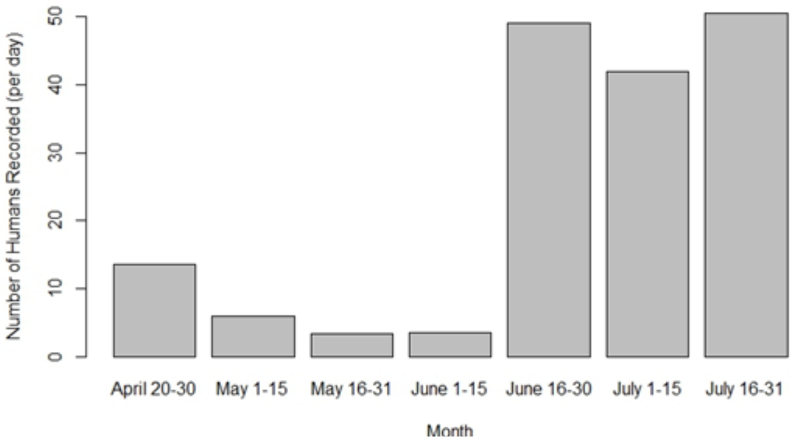
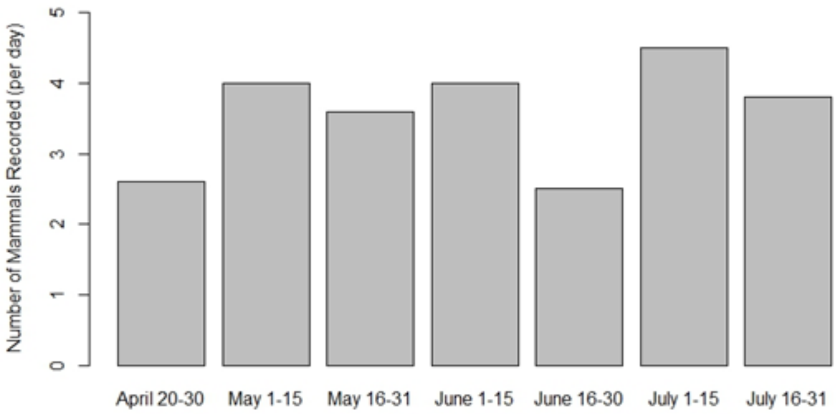
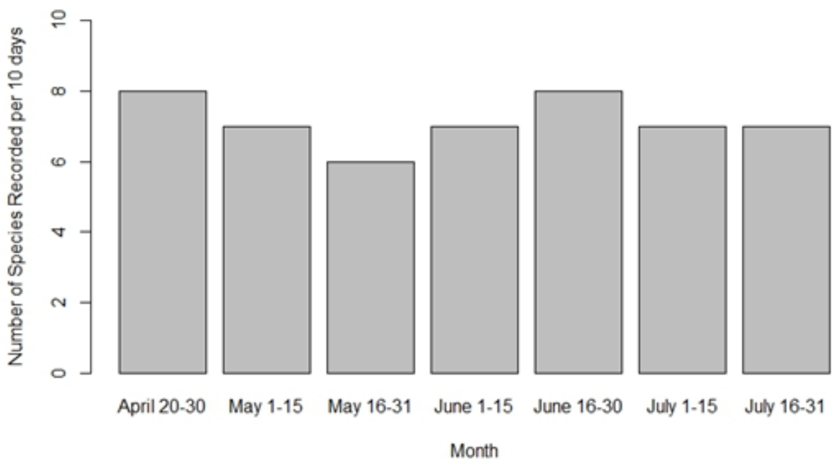


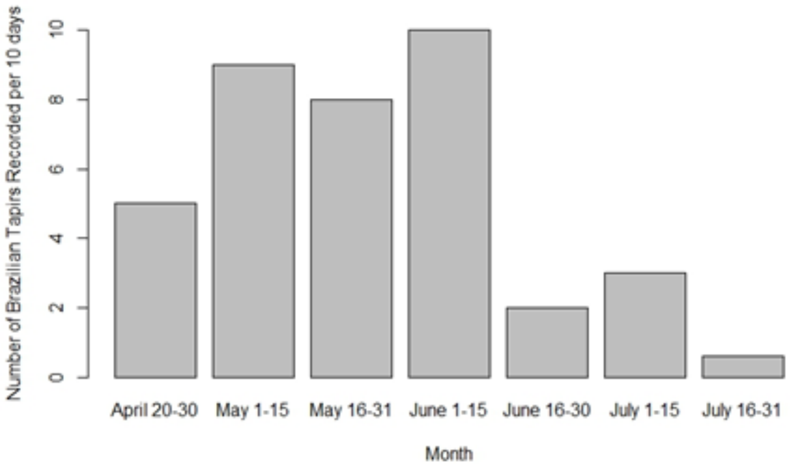
Figure 11 – Numbers of humans recorded (via camera trap) in Aguas Calientes per day in each half month from April to July

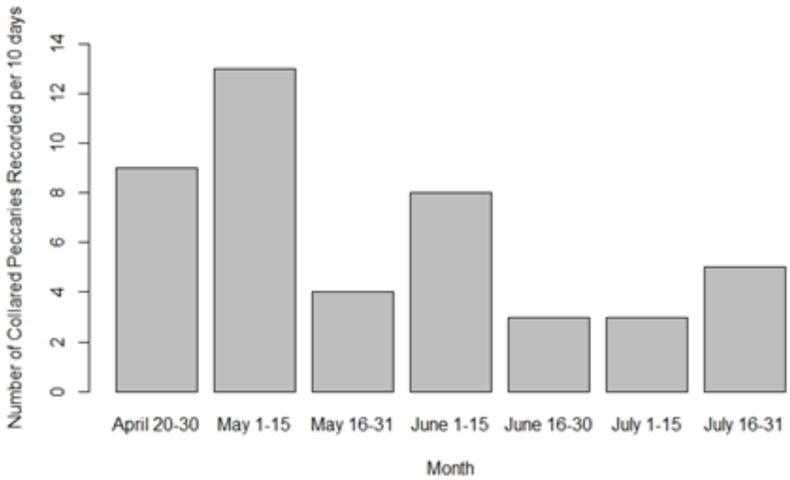


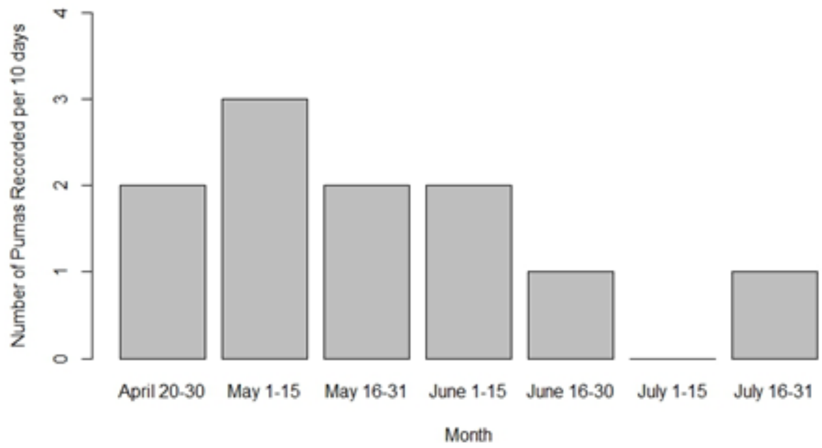


Figures 12 and 13 – Numbers of individual mammals recorded per day and number of mammal species recorded per 10 days, respectively, in Aguas Calientes in each half month from April to July

Interestingly, however, when looking at individual species there were noticeable effects from month to month. Numbers of Brazilian tapir (Figure 14), collared peccary (Figure 15) and puma (Figure 16) all followed roughly the same pattern, with numbers being highest in May-June, when there was least human presence, and decreasing quite rapidly over June and July when most humans were present.

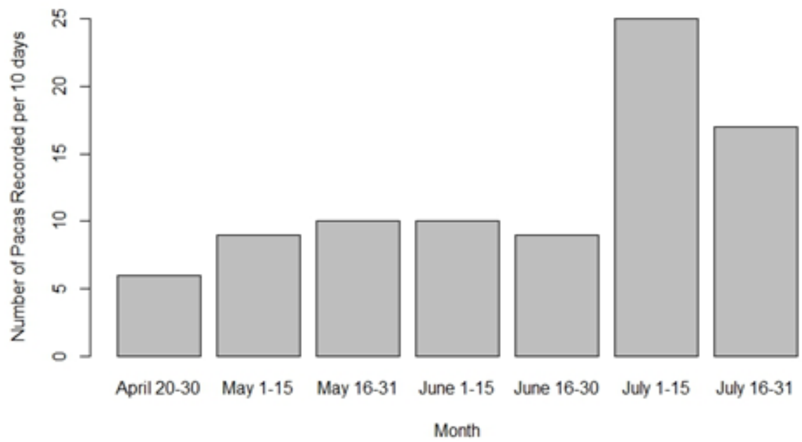


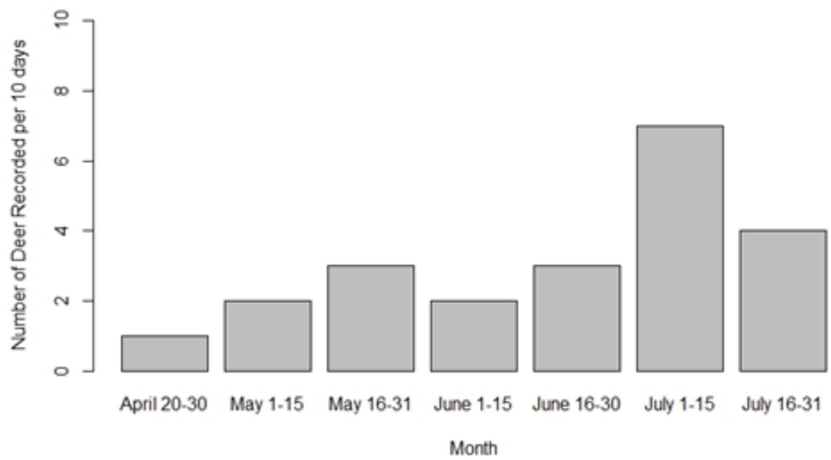




Figures 14, 15 and 16 – Numbers of Brazilian tapirs, collared peccaries and pumas recorded, respectively, (via camera trap) in Aguas Calientes per 10 days in each half month from April to July

Paca (Figure 17), red brocket deer (Figure 18) and jaguar (Figure 19) numbers also all showed similar trends to one another, but their patterns were opposite to those of the tapir, peccary and puma. Paca and red brocket deer numbers were actually highest in July, with numbers staying roughly similar between May and June. Jaguar numbers, on the other hand, showed a stable pattern, with numbers consistently being higher in the second half of each month.





Figures 17 and 18 – Number of pacas and deer recorded, respectively (via camera trap) in Aguas Calientes per 10 days in each half month from April to July

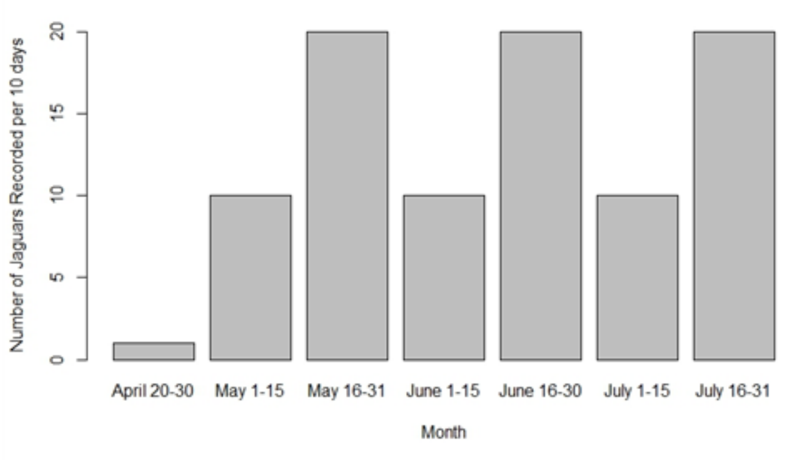


Figure 19 – Number of jaguars recorded (via camera trap) in Aguas Calientes per 10 days in each half month from April to July

Human Disturbance

Cameras along the main path recorded the highest numbers of humans, with all locations having either medium or high levels of human disturbance. Once camera trap locations were grouped into disturbance categories ('low', medium' or 'high'), the number of mammals recorded in each category (Figure 20) and the number of mammal species recorded in each category (Figure 21) were plotted. It was found that there was a significantly positive correlation between human disturbance and presence of mammals (Human presence: 0.38, SE = 0.12, F1,14 = 9.9, P = 0.007) with mammal numbers being highest in areas with high human activity and lowest in areas with low human activity. Number of mammal species varied slightly less, but there were still more species recorded in areas with high human disturbance than low disturbance.

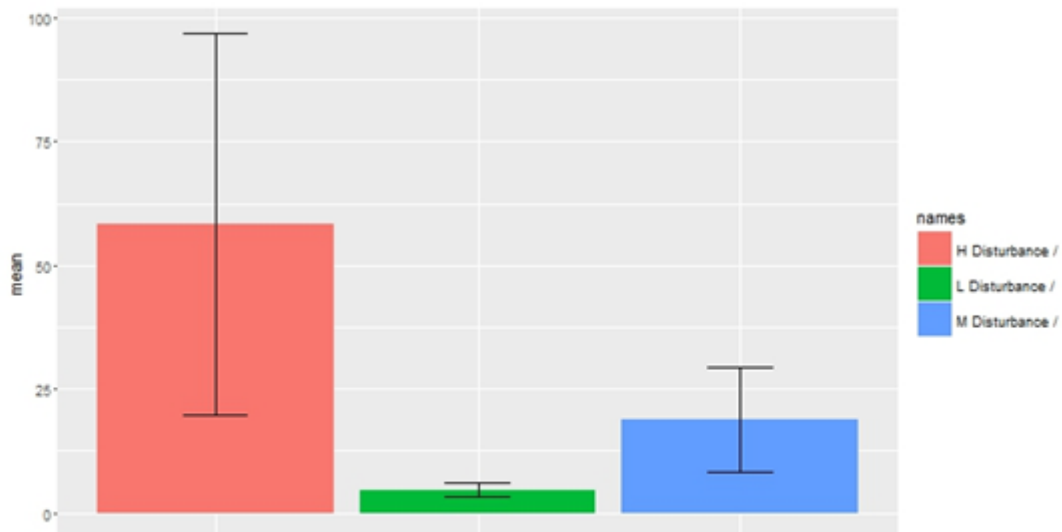


Figure 20 – Mean number of mammals recorded (y-axis) at camera trap locations with high (H), low (L) and medium (M) levels of human activity

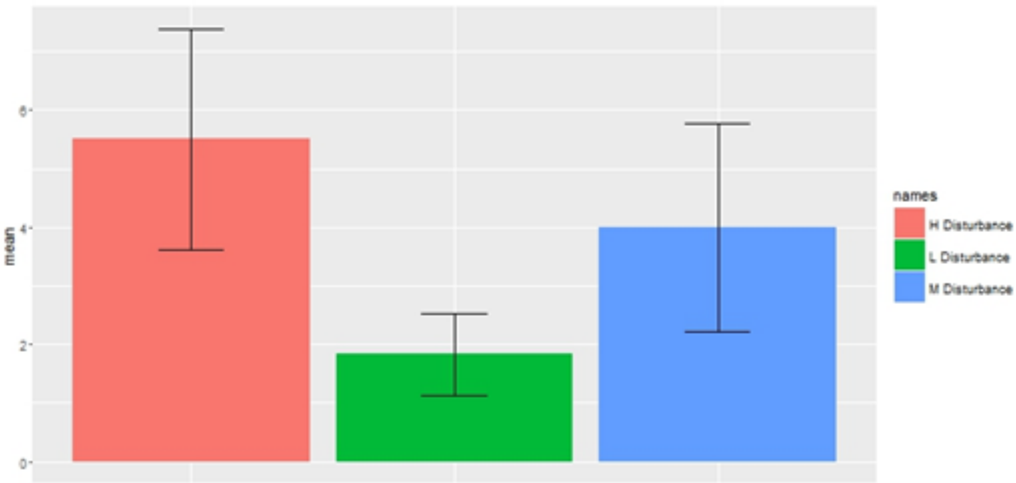


Figure 21 – Mean number of mammal species recorded (y-axis) at camera trap locations with high (H), low (L) and medium (M) levels of human activity

Discussion

The most prevalent human activity found to occur in Aguas Calientes was tourism (disregarding the high level of 'researcher' activity caused by the presence of the expedition team) and no evidence for harmful anthropogenic activities was found. It is also worth noting, however, that since the Peru Expedition team constituted the majority of humans recorded, the level of human activity was consequently much higher during the period of our stay than perhaps it would have been in our absence. Therefore, it is possible that our activities may have had some effect on the results of the study, as high levels of constant human presence have been known to have noticeable effects on wild animal behaviour (Hidinger 1996).

When comparisons were made between overall human activity and mammal activity, mammal activity remained fairly consistent throughout all hours of the day, showing no strong preference for particular times e.g. when humans were less active. However, the relationship between human and mammal activity patterns was found to be very close to significant – as was the case with several analyses of individual mammal species against human activity and also hour of the day – and had a few more weeks of data been obtained, it is very likely that these relationships would have proved to be significant. For this reason, future expeditions are encouraged to carry out more data collection for this project on return to the Shintuya/Aguas Calientes area.

The only two small gaps in Brazilian tapir activity seem to coincide with periods when human activity is at its peak. This may simply be a coincidence since tapirs generally show much lower diurnal activity anyway, but there is a possibility that human activity could be having some, albeit small, amount of influence on the activity of the Brazilian tapir since ungulates can often be sensitive to disturbance (George & Crooks 2006). Since, overall, most mammals were not actively choosing to avoid using the forest trails during times of day when human activity was generally high, this suggests that the majority of mammal species in Aguas Calientes remain undeterred by human presence. This does not mean that the mammals here are comfortable actually being around humans as that is completely unrealistic (Ciuti et al. 2012); the data simply indicates that the human activities in Aguas Calientes do not disrupt the daily activities of mammal species or deter mammals from using the forest trails at certain times of day.

Even though, overall, mammals did not appear to be affected by the varying levels of human presence over the months, a more focused analysis of individual species numbers reveals that, perhaps, humans were having an impact in some cases. For example, numbers of Brazilian tapirs, collared peccaries and pumas in the area all dramatically decreased from the second half of June and remained low until the end of July. Given that this was the period when human activity was extremely high, it is unlikely that this rapid reduction in numbers is coincidence. In the case of the peccaries and tapirs it is, perhaps, understandable that their numbers should drop, as it has been known for large ungulate species to quite drastically alter aspects of their behaviour and activity patterns when exposed to human disturbance (Zhou et al. 2013).

Completely contrary to the original prediction and to findings by other studies such as that by George & Crooks (2006) and Zhou et al.(2013), mammal numbers were highest in the areas with most human activity and lowest in the areas with lowest human activity. One theory for this is that the forest trails most used by humans in Aguas Calientes are also the most accessible travelling routes for many mammal species. Other than the main path, much of the trails followed a fairly steep incline, were very muddy or had areas of quite dense vegetation, whilst the main path was flat and on stable, dry ground for most of its length. Additionally, the main path was bordered on either side by a couple of metres of vegetation, leading to a small ditch and then a very steep slope upwards to a higher level of ground. It is possible that such geographical parameters meant that the main path was the only – or at least the easiest – available route for mammals to travel through this part of the forest. If this was the case, then it would certainly explain the unusual levels of mammal activity in these highly human-occupied areas.

With the exception of this unusual correspondence between areas of high human and mammal activity, the results presented in this study largely agree with those of other similar studies on the effects of human presence on wild mammal communities. Hidinger (1996), Rocha et al. (2012) and Salvador et al. (2011) all found no major differences in mammal diversity, abundance or species composition between sites with and without exposure to tourism. Hidinger (1996) and Zhou et al. (2013) also found that the effects of tourist presence depended largely on the specific mammal species – having seemingly positive impacts on some, negative impacts on others and some remaining unaffected – highly similar to the variety of patterns observed between different species in Aguas Calientes.

Conclusions

Overall, there was a mixture of evidence for the effects of human activity on the large mammal community in Aguas Calientes. The original predictions were found to be incorrect as there was no increase in mammal abundance with increasing distance from the human settlement and mammal activity was highest where there were the greatest numbers of humans. Human activity – largely in the form of tourism – appeared to have no significant impacts on the mammal community as a whole, though a few species exhibited declines following a sudden increase in human activity. A diverse range of mammal species was found to be present in Aguas Calientes, with the high likelihood that the actual species richness of this area is even higher than that observed in this study.

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Amphibians

Introduction

The amazon rainforest boasts one of the highest levels of biodiversity on the planet, specifically the western amazon (Finer et al. 2008). Due to many external pressures it is vital to determine the affects that humans have on species. The last major assessment of the global amphibian population was updated in 2004 therefore it is vital for studies to be continually carried out to monitor the population. This project aims to see the affect that human inhabitants have on the diversity of amphibians in the Manu biosphere, specifically at a tourist spot just down river from the village of Shintuya. The second aim was to gain a baseline of the diversity of the amphibians in the area. The study involved the use of visual encounter surveys and incidental captures to try and quantify the diversity of the amphibian population

Methods

The study conducted was a visual encounter survey involving in total 3 people per night. The surveys would commence at roughly 8pm at a designated transect point, which was marked on a GPS. The method involved two people searching through the jungle off to either side of the path. First a 5-minute leaf litter search was conducted by the searcher using their hands to sift through the leaf litter just off to the side of the path, then a 25-minute search was done deeper in the forest. Searchers were given a walk tax to monitor how far through the jungle they had travelled and to help them find their way back. If any amphibians were caught the searcher would note down the time, the distance into the forest, the height of the amphibian, the distance to the amphibian when spotted and the substrate the amphibian was caught on. The caught individuals were then placed in a plastic bag along with some of the substrate they were caught on and a small amount of water. They were then taken back to camp to have photos taken for identification purposes and released the next morning in the same place they were caught.

Additionally, an incidentals list was complied. This involved catching, or taking photos in the case of snakes, of any amphibians found while out doing any of the other projects. This was to aid in the documentation of the amphibian diversity of the area as a whole. The individuals caught were treated in the same way as those caught on transect.

Figure 1: example identification photos of *Hemiphractus helioi*

Results

Table 1: The diversity and abundance of species caught on transect.

A total of 21 transects were completed during our data collection phase, 6 close (<1km for camp), 9 mid (between 1-2km from camp), and 6 far (>2km from camp). On transect a total of 13 individuals were caught with there being 10 different species (Table 1). The most common species found was *Ameerega macero*, commonly known as the Manú poison frog, making up 23% of the individuals found.

The two figures below (Figures 1 & 2) show the abundance and diversity of amphibians caught at different distances from the human settlement. The distances are divided into close, mid, and far. As seen in figure 1 the abundance of amphibians increases as the distance increases from close to mid range but then there is a decrease to 0 at distances above 2km (far). The same is found in the diversity of amphibians, there is an increase in the diversity from close to mid range but then the diversity drops to 0 at further distances.

Species	Number of Individuals
Ameerega macero	3
Pristimantis sp1	1
Osteocephulus castaneicola	1
Hemiphractus helioi	1
Pristimantis ockendeni	1
Pristimantis buccinator	2
Teratohyla midas	1
Hypsiboas fasciatus	1
Ameerega hahneli	1
Ameerega sp1	1

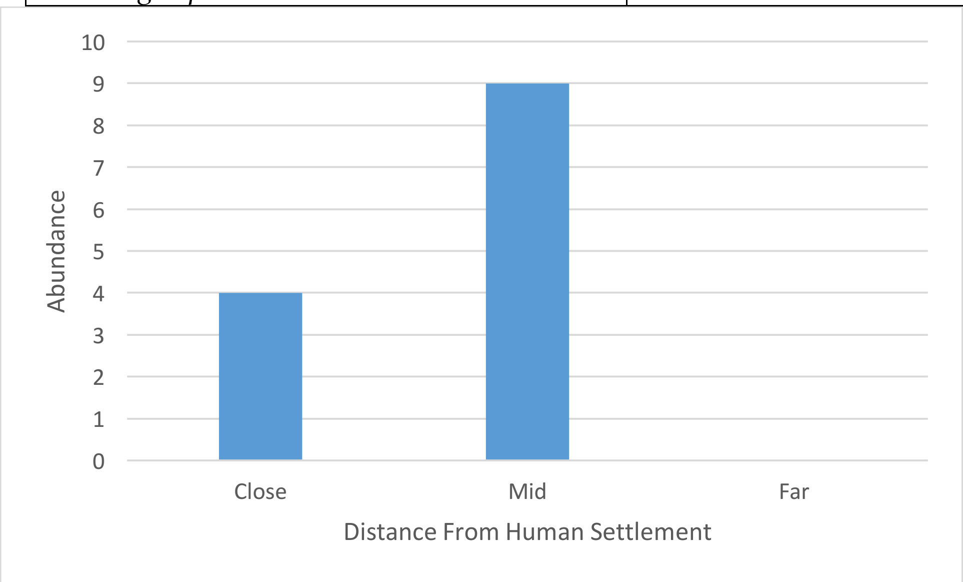

Figure 2: The abundance of amphibians at different distances from the human settlement.

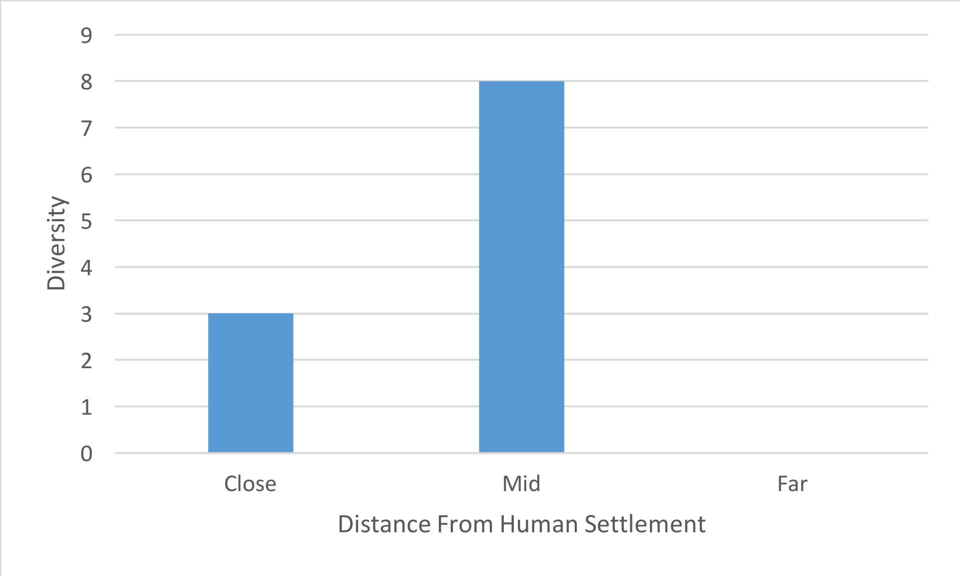

Figure 3: The diversity of amphibians at different distances from the human settlement.

In total 36 individuals were caught as incidentals comprising of at least 20 species, with there being some uncertainty about a few of the individuals caught. The individuals caught included snakes (*Micrurus narducci*), lizards (*Psuedo-gonatodes guanensis*), but the most common species found was the cane toad (*Rhinella margaritifera*).

Table 3: The diversity and abundance of amphibians marked as incidentals.

Discussion

The findings from our results suggest that amphibians do seem to increase in diversity and abundance increases the greater the distance from humans (Figures 1 & 2). However, no amphibians were caught at the furthest away transects, this may be due to the change in altitude, as the path used steadily climbed the further the distance from the camp. Additionally, some of the mid and close transects were done in muddier and more humid forest, which provides a different habitat for the amphibians. On one night specifically 6 individuals were caught in an area which was extremely muddy. This variability may affect the dispersion of amphibians in the forest as it might present a preferable habitat to the amphibians. This is in line with other studies that say the level of human disturbance may not affect the diversity of species (Rodrigues et al. 2004) but contradicts others (Ernst and Rödel 2005).

The original project was altered slightly due to the fact that the location of our camp had to be changed because of the arrival of an un-contacted tribe at the original village of Shipatiari. This meant we had to move to a smaller settlement further up river which only had 2/3 permanent residents and therefore less human disturbance. Additionally, when arriving at the Manú Learning Centre our sampling technique

Species	Abundance
Osteocephelus buckleyi	1
Psuedo-gonatodes guanensis	1
Rhinella margaritifera	6
Leptoderic annulate	1
Oreobates amarakaeri	2
Pristimantis ockendeni	2
Andenomra andreae	1
Allobates trilineatus	1
Gonatodes hasemani	1
Helicops angulatus	1
Hypsiboas boans	1
Micrurus narducci	1
Bolitoglossa calwelte	1
Ameerege sp1	1
Teratohyla midas	1
Pristimantis carvalhoi	1
Pristimantis buccinator	1
Allobates femoralis	1
Pristimantis toftae	2
Osteocephalus castaneicola	1
Unidentified	8

was changed. Originally the transects involved 3 people just walking along the path for a designated length, with one person looking ahead and one to either side. However, we were taught the new technique of using the walk-tax to be able to search through the forest which allowed more transects to be done each night and more of the jungle to be sampled. This method was open to some bias as it is a visual encounter survey there is human error, with some species being more distinctive, like the Manú poison frog with its bright colouration, and some people being more apt to this type of survey. Furthermore, due to there being three transects each night and having to be done late at night tiredness must be taken into account in both spotting individuals and in catching them. Additionally, we have experienced problems in the identification purposes due to inexperience and inadequate photos, though we believe we have done well in the circumstances.

This project was important in starting the collection of data on amphibians in an area of the Manú biosphere that research has not been done yet. Additionally, it is important to continually survey the Amazonian population as it is a key area of biodiversity (Finer et al. 2008). We believe that this will help other studies begin to get a better idea of what is to be found in this area and help in the conservation efforts on the CREES foundation and the Peruvian government by demonstrating the amazing biodiversity found here.

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Butterflies

Introduction

Butterflies are responsible for providing vital services to ecosystems such as the Madre de Dios region the Amazon Basin (Merckx et al, 2016). Within biomes such as this the species richness vastly outweighs that of temperate biomes as it can hold a third of the worlds insect populations (Collins and Thomas, 1991; Merckx et al, 2016). This is because there are many niches available to them due to the rainforest's highly heterogeneous nature (Collins and Thomas, 1991). Due to their economical value worldwide it is important to track changes in butterfly populations and the affects of human disturbance on their distribution. The aim of this research was to look at the affects of human disturbance across the Shintuya area of the rainforest.

Methods

The butterfly traps were set up along the main trails used by all other projects following along the main path used by tourists; up the hill where fewer people walked and along the "south trail" which was barely marked out. The bait used for the traps was made up of rotten banana and sugar fermented in the sun for a week. The bait was then placed on the tray (refer to figure 1) and hung 1m above the ground and left to gather butterflies over a 24 hour period. Each morning the traps were checked starting with those at the top of the hill walking back down and along the south trail. The butterflies were taken out using sandwich bags to carefully reach up and into the peak of the trap, surround the butterfly with the bag and pull it down and out through the gap between the tray and the net. Reaching into the sandwich bag, the butterfly was grabbed by its thorax being careful not to crush the abdomen. The wings were opened carefully and using the butterfly guide compiled by the Many Learning Centre, we identified the species and recorded as their code number. The butterfly was then marked with a silver pen and released away from the trap. Each day the data was written out taking note of the time, weather, site number, and whether it was a recapture as told by the silver pen mark.

Figure 4 - The butterfly traps used throughout our time. The blue tray was where the bait was placed.

Results

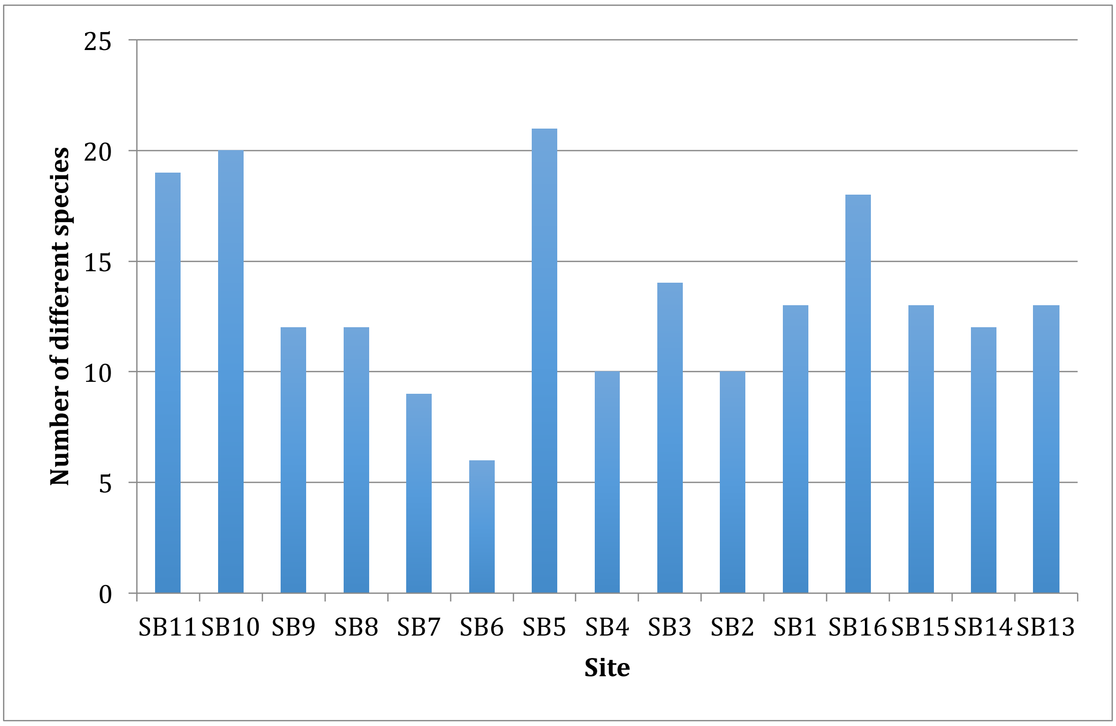

Figure 5 - The number of different species found at each site. Sites 16 through 13 were located in a less disturbed more muddy area. Site five was located just after the waterfall, a popular tourist attraction.

Figure 2 shows the number of different species found at each site. Sites 16 through to 13 were in the least disturbed area and 16 hung just above a small rivine. SB09 hung at the highest altitude.

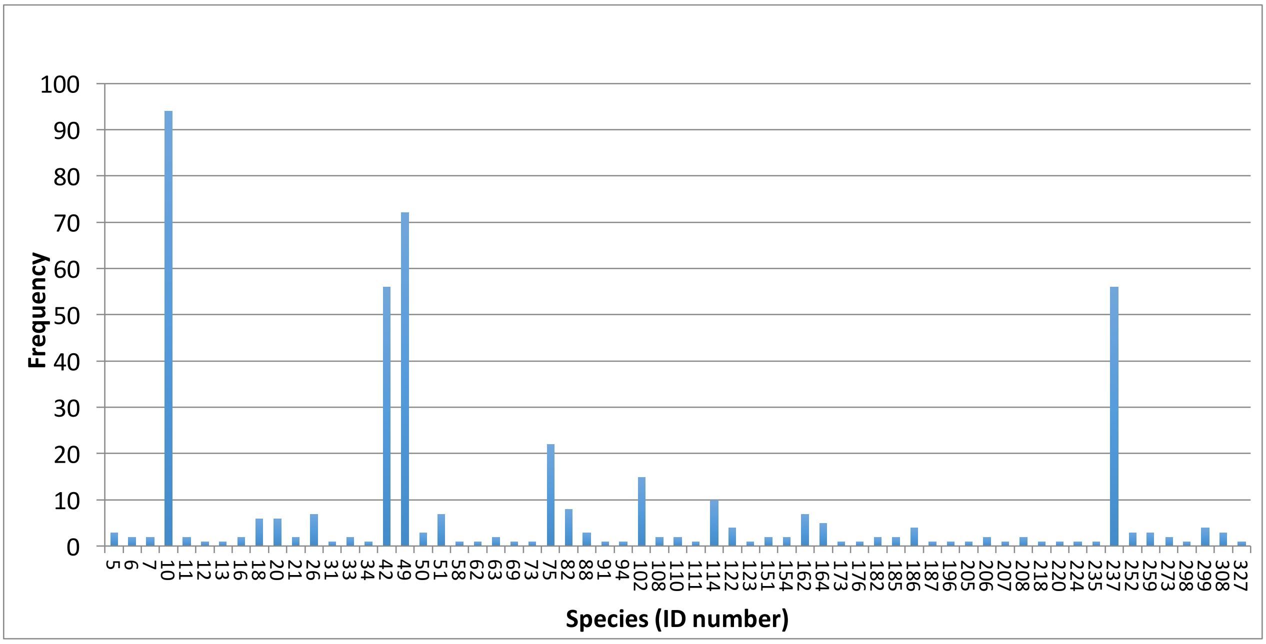

Figure 6 - Frequency of each species individually according to their species number.

Figure 3 shows the frequency of each individual species according to their species number. Species 10 were found most frequently followed by 49 then 42 and 237.

Discussion

Overall there were 450 individuals caught from 63 different species. The 4 most common species by name were the *Taygetis mermeria* (94 individuals), *Nessaea obrinus* (72 individuals), *Taygetis thamyra* (56 individuals) and *Cantonophele acontis* (56 individuals). Together they made up more than 60% of total captures.

Areas of high species diversity but low numbers of individuals show greater diversity and could hint that human disturbance could have an affect however, there were varying numbers of species found across all the sites, therefore no trend caused by human disturbance as shown by figure 2. Figure 3 shows large numbers of certain individuals but as identifying individuals can be a pedantic task, there could easily be error as the slightest difference of pattern in the wing could go unnoticed.

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Birds

Introduction

Peru, a country of a great variety of climates and thus a huge range of ecosystems containing many species, is one of the 10 most diverse, or megadiverse, countries in the world. It is thought to hold the second highest number of bird species in the world, after Colombia, with a total of 1825 species having been recorded, of which 105 are endemic to the country. (Angulo Pratolongo, 2009) However, this total number of bird species in Peru is not definite, with the South American Classification Committee stating that Peru has only 1721 bird species.

There are 121 globally threatened bird species in Peru according to the IUCN Red List, comprising many that are endangered or vulnerable. (BirdLife International, 2015) Habitat destruction, hunting for consumption, direct capture for the pet trade, and indirect capture in fishing nets, are the primary direct threats to birds in Peru. Other signification dangers are mining and petroleum extraction. The habitat destruction is principally due to montane, dry and Amazon forests being converted agriculture as human populations migrate further into these areas. (Angulo Pratolongo, 2009)

Peru contains the second-largest portion of the Amazon rainforest, with it covering 60% of the country. The Amazon rainforest in Peru encompasses the highland jungle that extends into the eastern foothills of the Andes, between heights of 1,000 to 3,800 m above sea level. These forests have a great diversity of life, including many endemic fauna, due to the changing altitudes and climates, with the temperature being cooler than in the lowlands.

In particular, the area Madre de Dios is found in Peru's lowland Amazon, which is globally recognised as one of the most biologically rich and unique areas on Earth. The Western Amazon hosts the highest number of avian species in the continent and is one of the most biodiverse areas on the planet. (Swenson et al, 2011)

Some parts of northern Madre de Dios contain a high density of lowland Guadua bamboo, occurring mainly in dense patches up to several acres in size. These areas of bamboo are a diverse habitat for many bird species, with 36 species in particular being characterised as Guadua specialists. (Harvey et al, 2014) The total number of bird species found in the region Madre de Dios is 966, with 22 of these being globally threatened species. There are also 14 endemic species found in Madre de Dios. (Lepage, 2015)

Studying birds along a gradient getting further away from human habitation will hopefully provide a clearer image of how bird species are affected by disturbance and destruction to tropical rainforests. The information obtained can be then used to advance the protection and conservation of bird species along tropical streams, proving that these habitats are valuable and vital to bird diversity.

When trying to protect any ecosystem and the wildlife it contains, it is important to understand how the structure of a habitat effects the populations and communities within it, a crucial aspect for linking habitat and niche selection with species diversity (Cintra and Naka, 2012). A specific use of environment can result from having longer lifespans, with birds possibly altering their microhabitat use in relation to local variation in forest structure. (Cintra and Naka, 2012) Hence, it is important to see and understand what effects differing levels of disturbance has on bird species along this particular environment The hypothesis was that there would be a lower abundance and diversity closer to camp and human habitation as there would be an increased level of disturbance from human activity.

Methods

The diversity and abundance of birds along human trails in Shintuya was recorded through visual encounter surveys and sound recordings. Line transects were used to compare the species richness along the paths, which had 8 transects leading from human habitation.

Teams then began their allocated line transect at 06:00, which is the average time of daybreak during July and August at the MLC and in Shintuya.

The line transects were carried out over 500m distances over a forty five minute time period in which every bird sighting and bird call was recorded.

Since all the transects 50m intervals with annotated high visibility marker tape, the locations of all visual and audio encounters of birds were recorded, noting the nearest 50m marker tape, time. Binoculars were used to enhance the accuracy of visual identification of encountered individuals with unfamiliar species checked against the latest edition of "Birds of Peru" by Princeton Field Guides. The bird calls of species present were learned, as well as use of sound recording equipment during transects for later audio analysis checked against "Voices of Amazonian Birds". A list compiled of species indicators and species which are most likely to be hunted was compiled with the help of the IUCN redlist.

Results

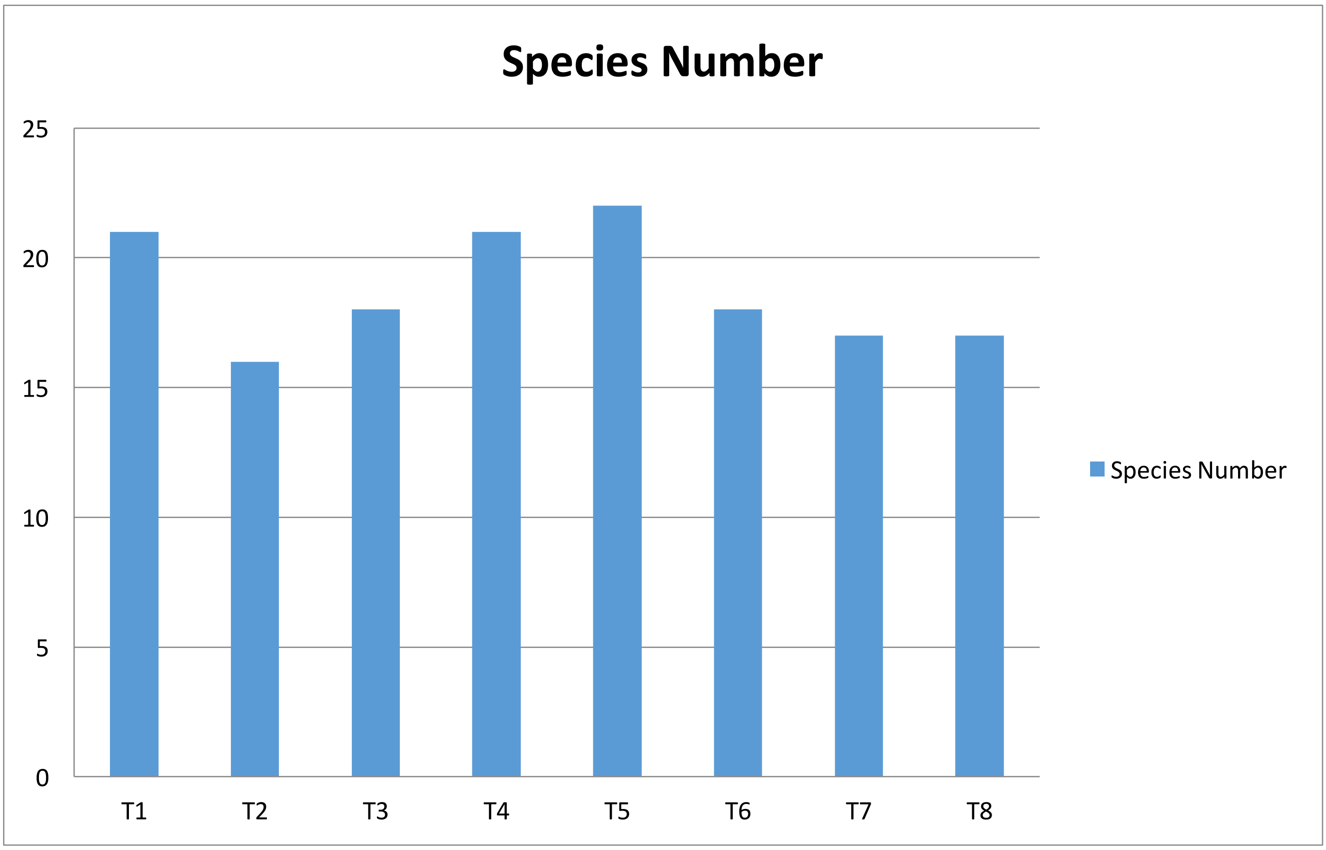

Figure 1: Barchart showing the number of species detected on each transect

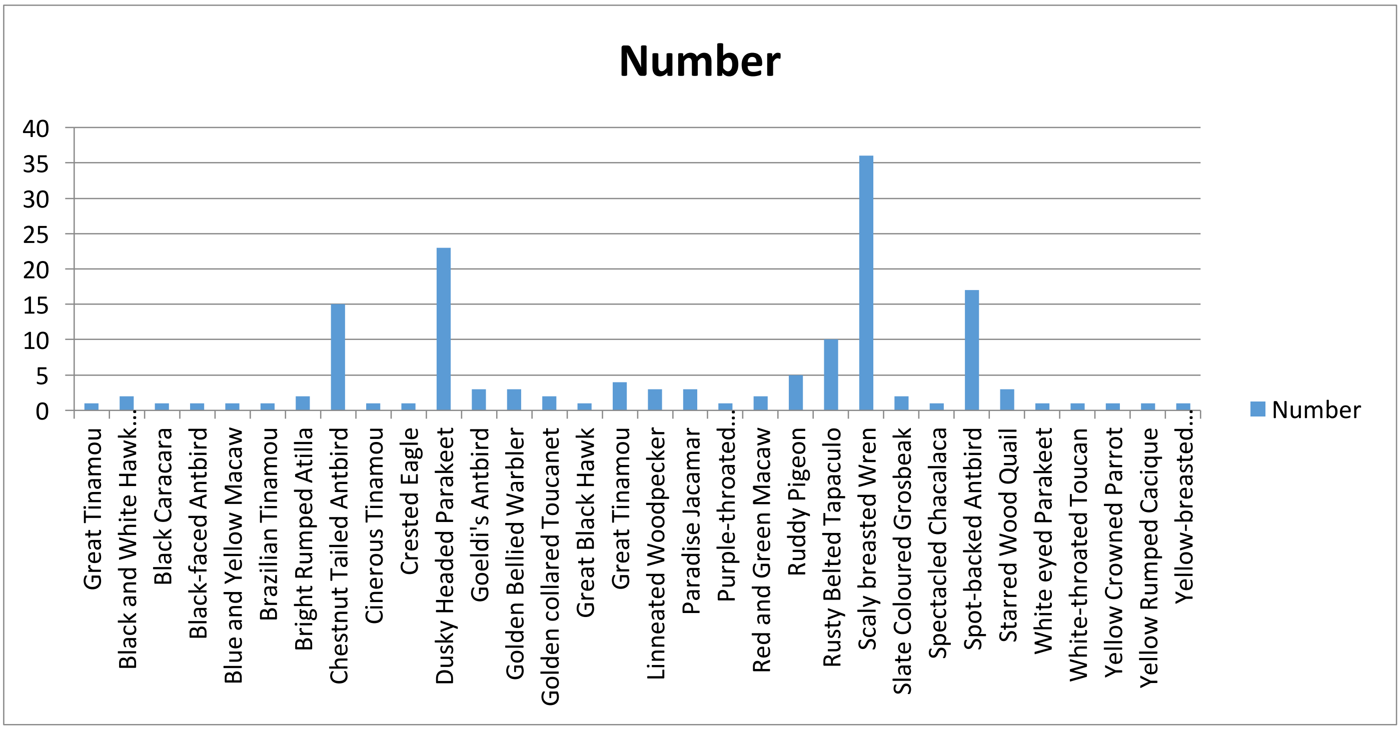

Figure 2: Barchart showing the frequency of species detected

Discussion

The hypothesis was that bird diversity and abundance varies between differing levels of disturbance in tropical rainforest ecosystem. From the results, it can be seen that there does not seem to be a definite difference in avian diversity and abundance the further from human habitation.

The data suggests that distance from human habitation does not have an effect on bird diversity and abundance. This is different to what was expected and contradicts the initial hypothesis.

Furthermore, one species, the dusky headed parakeet was third most frequently observed individual across all transects. This is especially unexpected as parrots are normally targeted for trophies, indicating that hunting pressure may not be great in this area for parrot species.

Certain bird behaviours were hard to record in this survey as transects were completed in dense forest and visual sightings were very rare. In previous expeditions, transects have been completed along rivers making it easier to observe avian activity due to the habitat being more open.

There were several visual sightings of birds flying that were primarily being high flying species such as parrot and macaws, the occasional toucan and toucanet was also observed.

As expected, there were a higher proportion of audio recordings at the 6am dawn chorus. This was consistent along transects, except for in transect 7 which is very close to a river which made audio recordings rather difficult to identify species upon return to camp.

This study has highlighted that even though these areas of tropical rainforest have been affected differently by human disturbance, and are continually affected by humans, due to the tourism of the area there does not seem to be much affect on species distribution. Similar research should be continued along with potential attention being paid specifically to focusing on studies carried out over a longer duration of time, allowing more data to be collected leading to more accurate results, this would allow for more consistent and reliable results. It is crucial more research is continued to highlight the true effects of human activity on avian species in the region.

Budget

Expenditure:

Flights	
£640 x 7 people	£4,480.00
Transport from Attalaya to Shipetiari	
US$2,079	£1,409.00
Supplies in Shipetiari	
US$315	£511.00
Accommodation at MLC	
US$15/night/person x 8 people x 6 nights	£460.00
Food at MLC	
US$5/person x 8 people x 7 days	£179.00
Food and Accomodation in Shipetiari	
=US$25/person/day x 8people x 42 nights	£5359.00
Miscellaneous food & accommodation during travel from Lima to MLC	£342.00
Equipment	
Additional Camera trap equipment	£300.00
Counterpart Costs	
Wages for 1 Assistant ($400)	£280.00
Miscellaneous equipment and consumables	£100.00

Training

First aid *(£30/person x 4 people)* £150.00

Total £13,570.00

Input:

Member contribution: *(£850/person x 7 people)*	£5950.00
Individual Fundraising Effort (*£150/person x 7 people)*	£1050.00
Team Fundraising Effort	£3282.22
Grant	£250.00
Grant	£700.00
Grant	£1,600.00
TREES	£200.00
University	£538.00
Total:	£13,570.00