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Foraging and nesting habits of the leafcutter ant

A research on the feeding and nesting habits of the three leafcutter ant species *Atta Cephalotes*, *Acromyrmex octospinosus* and *Acromyrmex volcanus* at Caño Palma Biological Station.

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CANADIAN ORGANIZATION FOR TROPICAL EDUCATION AND RAINFOREST CONSERVATION

A research for the Canadian Organization For Tropical Education And Rainforest Conservation

In coorperation with HAS hogeschool University of Applied Sciences.

hogeschool

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Foreword

This study on foraging and nesting habits of leafcutter ants is part of an undergraduate project from HAS hogeschool. This research was done for the Canadian Organization For Tropical Education And Rainforest Conservation, which is the organization running Caño Palma Biological Station. My personal goal for this study was to get experience in individually setting up a research and individually writing up a report.

This research is under guidance of Aidan Hulatt, who is the research coordinator of Caño Palma Biological Station, and Sander van Huijzen, who is supervising this research from the HAS hogeschool.

I would like to thank COTERC for giving me this opportunity to do my undergraduate project at their station. Also I would like to thank Aidan Hullat, Charlotte Foale and Sander van Huijzen for both supervising and all the help they gave me so I could successfully do this research.

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Summary

Leafcutter ants are invertebrates with an important role in the rainforests ecology. The effects of the leafcutters on the rainforest is much bigger than any other animal species or even all mammal species together. A significant amount of nutrients escape out of the fungus chambers back into the soil around the nests, which makes these nutrients available for other plants. The breakdown of specific plants also creates more competition between plants and plant species, this is the case because when bigger trees are eaten more light gets available at the bottom of the forest for the smaller plants.

Because of this important role in ecology COTERC was interested in a study on foraging and nesting habits of the different leafcutter ant species, also in this area no-one had ever done a research on these ants.

To get to know what the ants feed on and how much they forage for a seven week period four times a week seven nests were sampled for five minutes, in these sampling periods every single ant bringing foliage back to the nest was counted, also the type of foliage was recorded. Of these seven nests one was an *Acromyrmex octospinosus* nests, three were *Atta cephalotes* nests on the Cerro mountain and three were *Atta cephalotes* on normal elevation. An estimation on the mass foraged in one year will be made for these three groups. These three were also statistically compared for significant differences in types of foliage and amount of vegetation foraged.

It was found that *Acromyrmex octospinosus* forage around 32kg a year of vegetation mass. This is significantly lower than *Atta Cephalotes*, which is 177kg. No significant difference was found between the ants on the Cerro mountain and the ants on normal elevation, this was 179kg and 174kg. It was also found that rain at the time of sampling did not affect the amount of mass foraged.

Acromyrmex octospinosus foraged significantly more herb sections than *Atta cephalotes*, and *Atta cephalotes* foraged significantly more Fresh leaves.

It was also found that *Atta cephalotes* only has nests on the east side of the canal, *Acromyrmex octospinosus* and *Acromyrmex volcanus* had nests on both sides of the canal, though they are more common on the west side of the canal.

With the results this study provided the basic literature on leafcutter ants in this area is provided. Future Master or PhD or undergraduate student can use this information for a more specific research on certain aspects of the leafcutter ants.

1. Introduction

When hiking in one of Central America's national parks it is quite common to see trails of leaf cutter ants crossing the paths carrying leaves around. They leave an invisible scent on the trails they use in order to find their way back to the nest because sometimes the ants travel several hundred yards away from the nest. In these nests the ants bring the foliage to a fungus garden where the fungus feeds on the foliage the ants brought . The ants main food source is the fungus growing in these gardens.

The removal of foliage is an important process in the ecology of a rainforest. Leafcutter ants may account for the destruction of up to 17% of the total leaf production in tropical rainforests (Begon, 1996). This destruction however is sometimes estimated far higher. Some researches have suggested that as much as 80% of the apparent leaf damage in some Panamanian rain forests may be caused by Atta species. (*Wint, 1983*)(*Cherrett , 1989*) The effects of the leafcutters on the rainforest is much bigger than any other animal species or even all mammal species together. A significant amount of nutrients escape out of the fungus chambers back into the soil around the nests, which makes these nutrients available for other plants. The removal of specific leaves in the canopy also creates more competition between plants and plant species. This also gives smaller plants the chance to grow because when bigger trees are eaten more light gets available at the bottom of the forest. (*Hölldobler and Wilson, 1990*)

In a mature leaf cutter ant colony ants are divided into castes. Every cast is used for a different function. The different castes are males, queens, minims, minors, mediae and majors. The last four of these are in order of size (Small to Large). All of these castes besides the males are females. The queen is used to lay eggs and is the ant which starts the fungus garden by taking a little piece of fungus with her when leaving the nest she was born in. The males are only used for reproduction, they are used to inseminate the queen and die shortly after. Minims of *Acromyrmex octospinosus* stay in the nest only and take care of the larvae and fungus gardens. However minims of *Atta cephalotes* also clean and scrape leaf surfaces while the bigger ants are carrying them back to their nest. (*Weber, 1966, 1972*, *Hölldobler and Wilson, 1971*) Minors and mediae are used mostly for foraging. These two castes can also defend and fight when necessary. The majors are used only for defending the colony and clearing the paths. This cast is really strong compared to its body size, and is a little bigger than the mediae cast. (*Borgmeier, 1959*) The female castes besides the queen are believed to mate three to five times in their life and also lay eggs to produce new workers. (*Hölldobler &Wilson, 1990*)

Tortuguero is a village and name for an area in the north-east of Costa Rica. The area surrounding Tortuguero is full of rivers and canals. Around these canals lowland rainforest grows. These forests are full of palms and trees that can handle serious flooding. The area has an average rainfall of around 5000mm a year. On the west side of the canal flooding is quite normal in the raining season, when this area floods the whole jungle can be underwater. Besides the Cerro there are no hills or mountains in this area.

Figure 1.1 Cano Palma and its surroundings. (Source: maps.google.com)

This research is focused on these stunning creatures and was done for the Canadian Organization For Tropical Education And Rainforest Conservation (COTERC), who own and operate Cano Palma Biological Station. COTERC is a registered charity in Canada and funds the Caño Palma research station located in Tortuguero national park in the north-east side of Costa Rica. Cano Palma is focused on tropical education and rainforest conservation. The station is located next to a canal. This canal is called Cano Palma as well. On the other side of the canal there is a lodge called Vista al Mar. This lodge is also located next to the beach. The village San Francisco de Tortuguero is located south of Vista al Mar Hotel close to the mountain Cerro. (Figure 1.1)

Around Cano Palma Biological Station three different leaf cutter ant species can be found. *Acromyrmex octospinosus* is one of the three species. These ants are mostly found on the station's side of the canal. (Figure 1.1) One nest of this species can reach a population of around 14.000 individuals. *(Lewis , 1975)* This species can nest in rotting trees, fallen trees, soil, piles of organic waste and just under a layer of leaves. It is suspected that because of this wide variation of nesting places this ant can survive at Cano Palma's side of the canal, since this side of the canal is a very wet area which floods multiple times a year.

Acromyrmex volcanus is another species found in this area. It is considered both rare and hard to find by people who have been to the station for years. This species nests in the rainforests canopy roughly nine of the ten times. The one in the ten times this species nests in piles of leaf litter on the ground. This species is known to have smaller colonies and forage less leaves but more small herbs than the other two species. *(Wetterer, 1992, 1993)* This species is known to live in the Tortuguero area, but has never been studied before.

Atta cephalotes, the last species found in the area, is common on the east side of the canal. (Figure 1.1) This species nests can reach a population of several millions of individuals. *(Hälldobler & Wilson 1990)* In contrast with the other species *Atta cephalotes* can only nest in soil. This is probably why this species does not live on Cano Palma's side of the canal. It cannot survive on this side since the soil is too wet in this area and multiple times a year the west side of the canal gets flooded. The reason *Acromyrmex octospinosus* lives in the wet area is expected not to be because they prefer wet areas, but since in the other areas this species loses the competition with *Atta cephalotes*. Due to the large colony sizes the leaf cutter ants are among the most dominant invertebrate species in tropical wet forests. *(Wheeler, 1910)* Removal of foliage can highly affect vegetation growth in the surroundings of the colony's nests.

Cano Palma Biological Station wants a wide range of literature on all ecology topics in the stations area to attract people who would like to do their PhD or masters program in the lowland rainforest. It has never been described which ant species nest in which areas and what their basic foraging behavior is in the area around Cano Palma, this makes a study on the foraging and nesting habits of the leafcutter ants necessary before a detailed PhD or master research can be done.

Besides the need of literature on these species there is a certain interest in the effects of these ants, as the *Acromyrmex octospinosus* colonies seem to be less disturbing to the surrounding nature than the *Atta cephalotes* colonies are. Also since these species seem to forage on different types of organic material and different plant species in different areas, and a research in the Tortuguero area has never been reported. *(Wirth et al., 1997; Wetterer et al., 1998, Burd, 2000)* A research of the feeding and nesting habits of these ants focused specifically in the Cano Palma area would be a great addition to the stations and Costa Rica's literature.

At the end of this research conclusions are made about the type of foliage (fresh/fallen leaves, herbal parts, fruits, flowers, insect frass) the leafcutter ants forage on. Also an estimation on the total amount of vegetation mass foraged by the different ant species and elevations will be made. The nesting habits of the different ant species will be described as well.

2. Methodology

In order to get a clear view of the ant population in the area around Cano Palma a survey on the amounts and locations of nests of all leafcutter ant species has been done. In this survey eight *Atta cephalotes* nests have been found. All these nests have been found on the east side of the canal. All these nests were of a reasonable size. In contrast to the *Atta cephalotes* nests the *Acromyrmex octospinosus* nests are a lot smaller, this makes a research on the feeding habit of this species far harder than on the *Atta cephalotes* ants on the east side of the canal. In total five nests have been found. Many times *Acromyrmex octospinosus* ants were found but could not be followed back to a nest. Not only finding these nests is challenging, many of the *Acromyrmex octospinosus* nests have a population of under a few hundred as well. However, one bigger *Acromyrmex octospinosus* nest was found on the east side of the canal. After the sampling period two *Acromyrmex volcanus* nests was found as well.

The nests found in the surveys have been mapped out. (Figure 2.1) On this map the Ao stand for *Acromyrmex octospinosus* nests, the Ac stand for *Atta cephalotes* nests and the Av stands for *Acromyrmex volcanus* nests. The darker line on the middle of the figure is the canal. As seen on the figure, all *Atta cephalotes* nests were found on the east side of the canal and four out of five *Acromyrmex octospinosus* nests were found on the west side of the canal. One of the *Acromyrmex volcanus* nests was found on the west side and one on the east side of the canal.

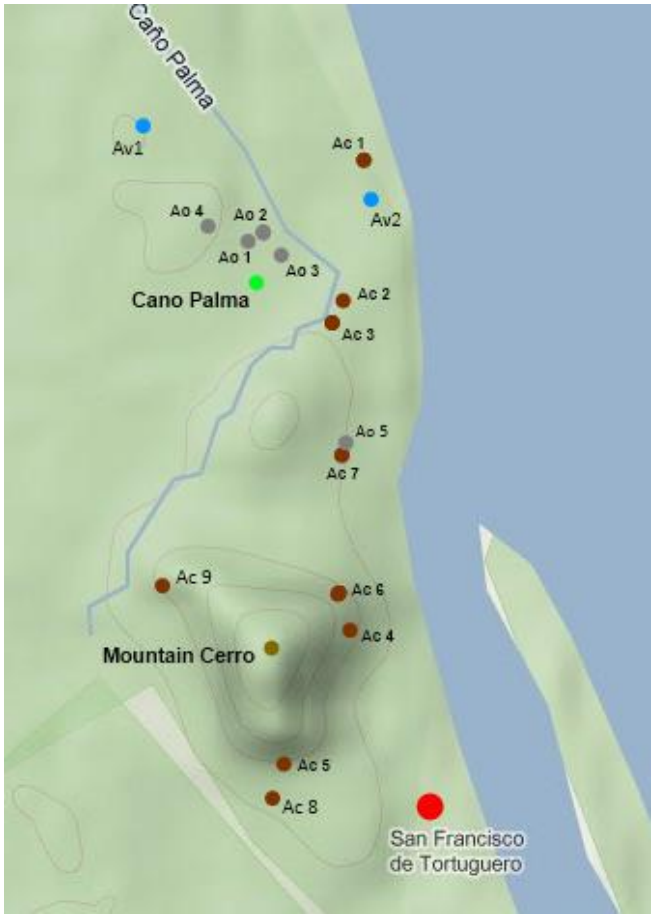

Figure 2.1: The nests found in the ant surveys (Source: maps.google.com)

Besides a comparison between the two species a comparison was made between the feeding habits of the *Atta cephalotes* ants on the Cerro mountain and the *Atta cephalotes* ants on the lower elevations as well. In a previous study it was described why leaf cutter ants are more common in secondary forest than in primary forests because shade-tolerant species, which are dominant plants in primary forests, are less attractive to the ants as pioneer vegetation is, which are dominant in secondary forest. (*Farji-Brener, 2001*) Because the area on Cerro mountain has a much older forest and has more dry soil than the lower ground areas it is interesting to know if the ants one the mountain actually forage less than the ants on the wetter and newer forest areas. Also tougher leaves are known to be less attracting to the ants than softer leaves. As older plants have tougher leaves, the newer forests are more attracting to the ants. (*Nichols-Oriana and Schultz, 1986*)

For a period of 7 weeks, four days a week six *Atta cephalotes* colonies and one *Acromyrmex octospinosus* colony were sampled. For this schedule was chosen because of the time available for this research a week, more sampling days and more weeks of sampling can always make results more significant. At every sampling moment every ant bringing their forage material back into the nest was

counted for five minutes. If one colony had more than one trail all trails were sampled for five minutes. For every ant it was written down what they were carrying. The regular materials carried back to the nest are fresh leafs, fallen leafs, herb sections, flowers, fruits and insect frass. (*Wetterer, 1992*) Any material that does not fit in one of those categories were marked as 'other'.

Of these six *Atta cephalotes* colonies three were located on the Cerro mountain and three were located on the land surrounding the Cerro, which has a lower elevation. The sampling was done at either 10 am or 3 pm. Twice a week at 10 am, twice at 3 pm. This way a more trustable estimation of the total amount of leaves harvested by the leafcutter ants can be given, since it is known that leaf cutter ants are most active between 12 and 6 pm. (*Wirth et al., 1997)* Once every three weeks it was checked if the leafcutter ants also foraged at night. If this would not have been the case only the daylight hours would have been used to make an estimation on the amounts of vegetation foraged. When the ants do forage at night all 24 hours would be used. To make the estimation in total amount of vegetation mass foraged by the ants once a week after the five minute sampling is done 10 random foliage materials were gathered from all the ant colonies. It is important this is done after the sampling period so the ants do not get disturbed during the sampling which may affect the results. This results in 60 per week, as the sampling period is seven weeks this mean 420 leaves in total this research. At the end of the sampling day all foliage is weighted and averaged, because the sampling always has the same time length (5 min) it is possible to calculate the vegetation mass of foliage foraged per day, per week, and per year. In the amount of total leaves foraged it was checked if there is a difference between the ants on the Cerro mountain and the ants on the lower ground areas. Also it was checked if there's a difference between the *Acromyrmex octospinosus* and *Atta cephalotes* nests. This was statistically tested by using the student's t-test. It was checked if there is a difference between the types of foliage foraged by the different species and different elevations as well. For this a One-Way Anova test was used.

Besides recording what kind of foliage the ants are carrying, also the plant species used for foraging are recorded when possible. If there is a difference between plant species foraged by the different ant species this would be described in the results. Also nest type (Soil, log, organic material) and the weather was reported, because these might have an influence on the amounts of leaves foraged by the ants.

3. Results

3.1 Vegetation mass foraged.

For a period of seven weeks the seven leafcutter ant nests were sampled on the amount of foliage brought back to nest. Also the foliage was weighted to be able to make an estimation on the total leaf mass foraged by these ants.

All ants foraged 13651 pieces of vegetation in all sampling periods together (Appendix 3), this however was not equally spread over the 7 weeks of sampling. (Figure 3.1.1) In the first few weeks of the sampling the ants were not very active. Later in the sampling period the ants got more active. This was the case with six of the seven colonies. The *Acromyrmex octospinosus* colony disappeared after five weeks of sampling. The *Acromyrmex octospinosus* colony is the only which did not get more active later in the sampling period.

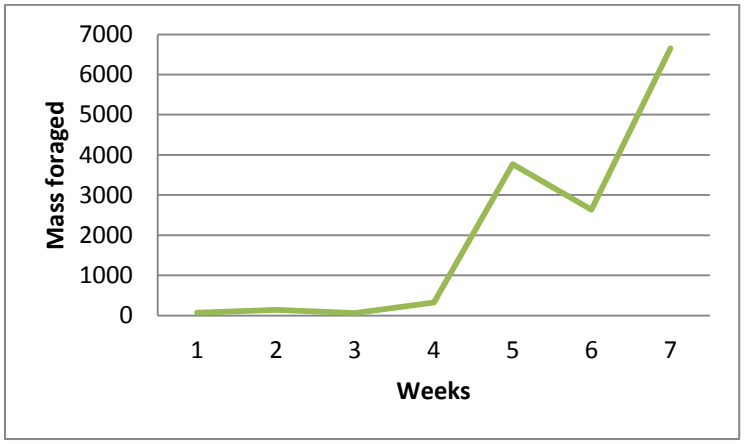

Figure 3.1.1 Total amount of foliage foraged in the different weeks of the sampling period by both species together.

Once a week 10 vegetation materials foraged by every colony were taken and weighted. Out of 120 foliage materials the average weight was 0.1 gram. There was no difference in weight between the *Acromyrmex octospinosus* and *Atta cephalotes* forage material.

The different nests all had a different foraging activity; some nests foraged far more than others. It was estimated how much vegetation the ants forage in kilograms a year. (Figure3.1.2) The average of all the colonies was 156 Kg.

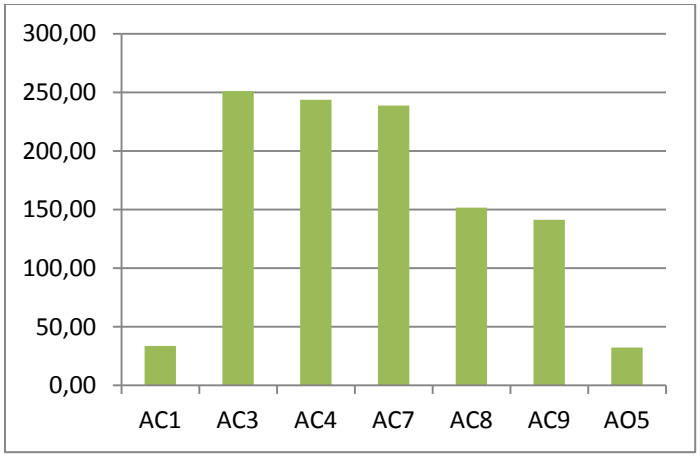

Figure 3.1.2 Estimation on the amount of vegetation foraged in one year in kilograms for the different nests.

A clear difference between the *Atta Cephalotes* and *Acromyrmex octospinosus* nests is visible. The average weight foraged for the *Atta Cephalotes* nests is 177 kg, for the *Acromyrmex octospinosus* nest this was only 32 kg. A significant difference was found between the mass foraged by the *Atta cephalotes* and *Acromyrmex octospinosus* nest. (P=0.043) (Appendix 1)

Between the *Atta Cephalotes* nests on the Cerro and on the lower ground there is almost no difference in average visible. The average of the nests on the Cerro is 179 kg mass foraged a year, and on the lower ground this is 174 kg a year. There was no significant difference (P=0,930) found between these values.

There was no significant difference found in mass foraged between rainy days and dry days. It was not possible to find a difference between colonies that nest in the soil and nests that nest in leaf litter since all the colonies sampled nested in the soil. However the ant surveys on the west side of the canal made clear that the *Acromyrmex octospinosus* nests barely foraged and did not forage on a consistent basis. Some *Acromyrmex* octospinosus nests were found foraging once, and then not seen for a few weeks. Also some nests appeared and disappeared in places in a matter of days. Two *Acromyrmex volcanus* nests were found, one on each side of the canal. Both were only found foraging at night, when the nests were visited during the day no ants were seen.

3.2 Types of foliage

At every five minute sampling period the types of foliage that were foraged on by the different colonies was recorded. These types were recorded as one of the following: fresh leaves, fallen leaves, herb sections, fruit, flowers, insect frass and other. During this research the forage type insect frass was never recorded, so this type was left out of the statistic analyses.

The types of foliage foraged by the two ant species do not show the same distribution. (Table 3.2.1) A significant difference between the amount of fresh leaves *Atta cephalotes* and *Acromyrmex octospinosus* foraged was found. (P=0.34) (Appendix 2) *Atta cephalotes* colonies forage more fresh leaves in five minutes than *Acromyrmex octospinosus* colonies do.

The herb sections however were significantly foraged more by the *Acromyrmex octospinosus*. (P=0.22) (Appendix 2) Not a single ant carrying insect frass was seen during this research.

No difference was found between the Cerro and lower elevation levels . Also the weather did not affect the types of foliage foraged.

Table 3.2.1 The types of foliage foraged by the different ant species in percentage of total foliage by the species.

Types of foliage	Ao	Ac
Total Fresh leaves	58.3%	95.0%
Total Fallen leaves	9.1%	3.0%
Total Herb sections	27.0%	1.1%
Total Flowers	4.2%	0.6%
Total Fruits	1.0%	0.2%
Total other	0.3%	0.1%

3.3 Plant species used for foraging

For one week all plants the ants foraged on were found and determined. This happened after the seven week sampling period of the foliage types and vegetation mass. Six plant species got determined; *Philodendros sp*., *Hibiscus rosa-sinesis*, *Terminala catappa* (Indian Almond), *Dalbergia sp*., *Hura crepitans* and *Piper sp*. All these six were foraged on by the *Atta cephalotes*. During the research it was found that not only trees were foraged on by both species, also many times little plants and herbs were used for foraging.

4. Discussion and conclusions

4.1 Results in the literature

As seen in the results the leafcutter ants got more active as the sampling period progressed. In the first sampling week less than a 1000 ants were found bringing foraging material back to their nest. In the 7th week however this was almost 7000. This most likely has to do with the lack of rainfall and low humidity in this area during the first few weeks of the sampling, the heat made the ants less active, which is surprising since in few researches it was stated that ants are more active when it is dry. (*Pinter-Wollman, 2012, Viana et. al.,2004*) But however, no significant difference was found in mass foraged between rainy and dry days in this research, though this may be affected by the fact that the weather at the time of sampling was recorded, and not the weather of the hours prior to the sampling minutes. If it rains a lot right before the sampling minutes, quite often it was seen that the ants were less active since there were puddles on the ant's trails which they could not cross.

The results also showed that *Atta cephalotes* foraged significantly more than *Acromyrmex octospinosus*. *Atta cephalotes* foraged an estimated average of 177kg a year, while *Acromyrmex octospinosus* foraged 32kg a year. This is also what was hypothesized, as the *Acromyrmex octospinosus* has smaller colonies and less room for fungus chambers as their nests are generally in trees or leaf-litter. The *Atta cephalotes* can have multiple big fungus chambers since underground there is all space the ants would like to use. This limits *Acromyrmex octospinosus* in the amount of leaves they can bring to their nest to get eaten by the fungus. However *Acromyrmex octospinosus* colonies almost never over estimated the amount of leaves their fungus could handle, in contrast with the *Atta cephalotes* colonies which often has loads of leaves right in front of the nest as there was not space in the nest for these leaves. In another study it was proven that leafcutters drop their leaves when there is no space in the fungus chamber for the leaves to be eaten by the fungus. (*Hart, 2001*)

No difference in amount of foliage between the *Atta cephalotes* ants on the Cerro and on the lower ground elevations was found. The ants on the normal elevation foraged 174kg a year, where the ants on the Cerro foraged 179kg a year. It was expected that the ants on the lower elevations foraged more since they live in a more secondary forest than the ants on the Cerro, which is a much older forest. This was expected because a recent study showed that leafcutter ants are more active in secondary rainforests than in primary rainforests. (*Farji-Brener, 2001*) However during the sampling it was found that one of the three colonies that nests on the Cerro actually got all their foliage from the lower elevated area right next to the Cerro. The ants walked out of the rain forest to forage in peoples gardens and on the beach plants. Also all the nests on the Cerro were not located near the top of the Cerro, as they were all located at the edges of the mountain in just a little elevated areas where the forest is actually not much different than the forests on the lower elevations. This almost certainly has affected the amount of foliage foraged, and makes it logical that there was no difference between the nests on the Cerro and lower elevations.

As seen in the results no difference was found in weight of foliage between the two ant species. Both species' average weight for one foliage material was 0.2 grams. This is surprising since the *Acromyrmex* are generally bigger and even heavier than *Atta cephalotes* ants, which would indicate that they are stronger ant can carry heavier leaves. (*Borgmeier, 1959*) This however might have to do with the fact that *Acromyrmex* foraged many herbs and flowers, which are a certain size which means the ants are less able to choose their load size their selves. This cannot be proven unless in a future research the weight of only leaves will be measured.

Ant surveys west side of the canal made clear that the *Acromyrmex octospinosus* nests barely foraged and did not forage on a consistent basis. Some *Acromyrmex octospinosus* nests were found foraging once, and then not seen for a few weeks. Also some nests appeared and disappeared in places in a matter of days. This indicates that these ants most likely move their nests quite easily and

are able to live on just one day of foraging for a few weeks. The only *Acromyrmex octospinosus* nest that was found foraging consistently was the nest in the soil on the east side of the canal, which means the consistency of the leafcutters likely has to do with the space for fungus in the chambers, since nests in the soil can easily expend the fungus chamber when too much foliage is brought back.

Often *Acromyrmex Octospinosus* nests were found on the west side of the canal but could not be traced back to a nest. The nest on the east side of the canal, which was used for sampling, was most likely killed by the *Atta cephalotes* nest which was positioned roughly 5 meter from the *Acromyrmex octospinosus* nest, which is known to be a common thing for *Atta cephalotes* to do. (*Tom Mason, personal communication*) This and also the lack of more *Acromyrmex octospinosus* nests on the east side of the canal indicates that these ants do not prefer the wet west side of the canal, but simply do not survive in the dry area's because in these areas it loses the competition with *Atta cephalotes*.

Two *Acromyrmex volcanus* nests were found during this study, one on each side of the canal. Both were only found foraging at night, when the nests were visited during the day no ants were seen. This could indicate that this species is nocturnal. However in one of the only studies on this species this was not stated. (*Wetterer et al., 2005*)

A significant difference found in the foliage types between the two ant species. The *Acromyrmex octospinosus* foraged significantly more herb sections than *Atta cephalotes*, and the other way around with fresh leaves. This was known and stated in other researches, however this was never proven or referenced, which may mean that it was never proven to be significantly different. It was also seen that the *Acromyrmex octospinosus* more often got leaves from small bushes than the *Atta cephalotes* did, and *Acromyrmex octospinosus* ants were never found foraging more than roughly 10 meters away from their nest, where *Atta cephalotes* sometimes walked at least 50 meters to get their foliage materials. The fact that never in this study an ant was found carrying insect frass most likely has to do with the inability of the researchers to recognize insect frass from a piece of dirt or a piece of log. These two were both marked as other, so insect frass was basically marked as other during this research.

During the research six plant species were the ants foraged on were determined. This is far too less to find differences between the two ant species and also between the different nest elevations. To get a good view on what species are foraged by the ants a research should be focuses on this, and be repeated in the different seasons (Dry season, Rain season) as this may influent the species the ant forage on. It is known that different leaf cutter ant species have different fungus species, however these fungus species are all of the same family. (*Sunjian, 2012*) This is a reason that the different species need different plant species to forage on, as every plant species has a different chemical structure. (*Farji-Brener, 2001*)

4.2 Conclusions, advises and recommendations

It can be concluded that *Atta cephalotes* forages more than *Acromyrmex octospinosus*. Also *Atta cephalotes* forage more fresh leaves in comparison to the other forage types. This is also the case with herb sections but the other way around, *Acromyrmex octospinosus* forage more herb sections than *Atta cephalotes*. The *Atta cephalotes* ants are estimated to forage 177kg a year of vegetation material, which is a little more than the 150kg average found in recent studies. (*Soszka, 2010*) The *Acromyrmex octospinosus* was estimated to forage 32kg a year. Which is a little more than the closely related *Acromyrmex coronatus* foraged in this same study.

In a future research more focus should be put on the plant species the ants forage on. Also a study on the nest moving and foraging behavior of *Acromyrmex octospinosus* and *Acromyrmex volcanus* would be a good addition to this study , as this study has not been able to make conclusions on this. Besides that the base literature for a Master or PhD research on leafcutters in this area is made.

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Appendix 1 T-test

Independent Samples Test

		Levene's Test for Equality of Variances		t-test for Equality of Means						
									95% Confidence Interval of the Difference	
		F	Sig.	t	df	Sig. (2-tailed)	Mean Difference	Std. Error Difference	Lower	Upper
Total_foliage	Equal variances assumed	11,860	,001	2,041	179	,043	69,56384	34,08039	2,31283	136,81485
	Equal variances not assumed			5,079	178,477	,000	69,56384	13,69638	42,53617	96,59151

Appendix 2 Anova

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Fresh_leaves	Between Groups	103192,622	1	103192,622	4,578	,034
	Within Groups	4035059,312	179	22542,231		
	Total	4138251,934	180			
Fallen_leaves	Between Groups	34,014	1	34,014	1,202	,274
	Within Groups	5065,356	179	28,298		
	Total	5099,370	180			
Herb_section	Between Groups	146,072	1	146,072	5,334	,022
	Within Groups	4902,238	179	27,387		
	Total	5048,309	180			
Flower	Between Groups	,055	1	,055	,023	,881
	Within Groups	441,127	179	2,464		
	Total	441,182	180			
Fruit	Between Groups	,005	1	,005	,002	,962
	Within Groups	408,239	178	2,293		
	Total	408,244	179			
Other	Between Groups	,008	1	,008	,077	,782
	Within Groups	18,324	179	,102		
	Total	18,331	180			

Appendix 3 Results used for graphs and estimations

F stands for Foraging

A stands for Activity

FR.L. stands for Fresh leaves

FA.L. stands for Fallen leaves

HS stands for Herb Sections

FL stands for Flowers

FR stands for Fruits

Date	Week #	Day of week	Weather	Nest	F	A	if <10	FR.L.	FA.L.	HS	Fl	FR	Other	TOTAL
27-aug	week1	Monday	Dry	AC1	Y	Y	2							2
27-aug	week1	Monday	Dry	AC3	Y	Y		8	1	0	0	0	1	10
27-aug	week1	Monday	Dry	AC4	N	N								0
27-aug	week1	Monday	Dry	AC7	y	y		9	1	0	0	0	0	10
29-aug	week1	Wednesday	Dry	AC1	N	N								0
29-aug	week1	Wednesday	Dry	AC3	n	n								0
29-aug	week1	Wednesday	Dry	AC4	n	n								0
29-aug	week1	Wednesday	Dry	AC7	n	n								0
1-sep	week1	Saturday	Dry	AC1	n	n								0
1-sep	week1	Saturday	Dry	AC3	n	y								0
1-sep	week1	Saturday	Dry	AC4	n	n								0
1-sep	week1	Saturday	Dry	AC7	y	y		38	0	0	0	0	0	38
2-sep	week1	Sunday	Dry	AC1	n	n								0
2-sep	week1	Sunday	Dry	AC3	n	y								0
2-sep	week1	Sunday	Dry	AC4	n	n								0
2-sep	week1	Sunday	Dry	AC7	y	y	7							7
4-sep	week2	Tuesday	Dry	AC1	y	y	5							5
4-sep	week2	Tuesday	Dry	AC3	y	y	6							6
4-sep	week2	Tuesday	Dry	AC4	n	n								0
4-sep	week2	Tuesday	Dry	AC7	y	y		12	0	0	0	0	0	12
7-sep	week2	Friday	Dry	AC1	n	n								0
7-sep	week2	Friday	Dry	AC3	n	n								0
7-sep	week2	Friday	Dry	AC4	n	n								0
7-sep	week2	Friday	Dry	AC7	n	y								0
7-sep	week2	Friday	Dry	AC8	n	n								0
7-sep	week2	Friday	Dry	AC9	n	n								0
7-sep	week2	Friday	Dry	AO5	y	y	8							8
8-sep	week2	Saturday	Dry	AC1	n	n								0

8-sep	week2	Saturday	Dry	AC3	n	n								0
8-sep	week2	Saturday	Dry	AC4	n	n								0
8-sep	week2	Saturday	Dry	AC7	n	y								0
8-sep	week2	Saturday	Dry	AC8	n	n								0
8-sep	week2	Saturday	Dry	AC9	n	n								0
8-sep	week2	Saturday	Dry	AO5	y	y		12	2	49	0	0	0	63
9-sep	week2	Sunday	Dry	AC1	n	n								0
9-sep	week2	Sunday	Dry	AC3	n	n								0
9-sep	week2	Sunday	Dry	AC4	n	n								0
9-sep	week2	Sunday	Dry	AC7	y	y		29	2	0	0	0	1	32
9-sep	week2	Sunday	Dry	AC8	y	y	1							1
9-sep	week2	Sunday	Dry	AC9	y	y	5							5
9-sep	week2	Sunday	Dry	AO5	y	y		6	1	3	1	0	1	12
11-sep	week3	Tuesday	Dry	AC1	n	y								0
11-sep	week3	Tuesday	Dry	AC3	n	n								0
11-sep	week3	Tuesday	Dry	AC4	n	n								0
11-sep	week3	Tuesday	Dry	AC7	n	y								0
11-sep	week3	Tuesday	Dry	AC8	n	y								0
11-sep	week3	Tuesday	Dry	AC9	n	n								0
11-sep	week3	Tuesday	Dry	AO5	y	y	8							8
13-sep	week3	Thursday	Dry	AC1	n	y								0
13-sep	week3	Thursday	Dry	AC3	n	y								0
13-sep	week3	Thursday	Dry	AC4	n	y								0
13-sep	week3	Thursday	Dry	AC7	n	y								0
13-sep	week3	Thursday	Dry	AC8	y	y	4							4
13-sep	week3	Thursday	Dry	AC9	n	y								0
13-sep	week3	Thursday	Dry	AO5	y	y		2	0	1	4	0	0	7
15-sep	week3	Saturday	Dry	AC1	n	n								0
15-sep	week3	Saturday	Dry	AC3	n	n								0
15-sep	week3	Saturday	Dry	AC4	n	n								0
15-sep	week3	Saturday	Dry	AC7	y	y	5							5

15-sep	week3	Saturday	Dry	AC8	n	n								0
15-sep	week3	Saturday	Dry	AC9	n	n								0
15-sep	week3	Saturday	Dry	AO5	y	y		26	4	2	3	0	0	35
16-sep	week3	Sunday	Dry	AC1	n	n								0
16-sep	week3	Sunday	Dry	AC3	n	n								0
16-sep	week3	Sunday	Dry	AC4	n	n								0
16-sep	week3	Sunday	Dry	AC7	n	n								0
16-sep	week3	Sunday	Dry	AC8	n	n								0
16-sep	week3	Sunday	Dry	AC9	n	n								0
16-sep	week3	Sunday	Dry	AO5	n	y								0
17-sep	week4	Monday	Dry	AC1	n	y								0
17-sep	week4	Monday	Dry	AC3	n	y								0
17-sep	week4	Monday	Dry	AC4	n	n								0
17-sep	week4	Monday	Dry	AC7	y	y	3							3
17-sep	week4	Monday	Dry	AC8	y	y		8	1	0	2	0	1	12
17-sep	week4	Monday	Dry	AC9	y	y	2							2
17-sep	week4	Monday	Dry	AO5	y	y	5							5
18-sep	week4	Tuesday	Dry	AC1	n	y								0
18-sep	week4	Tuesday	Dry	AC3	n	y								0
18-sep	week4	Tuesday	Dry	AC4	n	n								0
18-sep	week4	Tuesday	Dry	AC7	y	y	3							3
18-sep	week4	Tuesday	Dry	AC8	y	y	9							9
18-sep	week4	Tuesday	Dry	AC9	y	y	6							6
18-sep	week4	Tuesday	Dry	AO5	y	y	4							4
20-sep	week4	Thursday	Dry	AC1	n	y								0
20-	week4	Thursday	Dry	AC3	n	y								0

sep														
20-sep	week4	Thursday	Dry	AC4	n	y								0
20-sep	week4	Thursday	Dry	AC7	y	y		21	6	41	3	1	0	72
20-sep	week4	Thursday	Dry	AC8	n	y								0
20-sep	week4	Thursday	Dry	AC9	n	y								0
20-sep	week4	Thursday	Dry	AO5	y	y		27	1	2	1	0	0	31
22-sep	week4	Saturday	Dry	AC1	n	y								0
22-sep	week4	Saturday	Dry	AC3	y	y	1							1
22-sep	week4	Saturday	Dry	AC4	y	y		11	0	0	0	0	0	11
22-sep	week4	Saturday	Dry	AC7	n	y								0
22-sep	week4	Saturday	Dry	AC8	y	y		85	10	6	2	0	0	103
22-sep	week4	Saturday	Dry	AC9	y	y		40	2	0	0	0	0	42
22-sep	week4	Saturday	Dry	AO5	y	y		5	2	11	0	0	0	18
25-sep	week5	Tuesday	Dry	AC1	n	y								0
25-sep	week5	Tuesday	Dry	AC3	y	y	9							9
25-sep	week5	Tuesday	Dry	AC4	y	y	2							2
25-sep	week5	Tuesday	Dry	AC7	y	y		13	4	1	0	0	1	19
25-sep	week5	Tuesday	Dry	AC8	y	y		171	7	15	3	0	2	198
25-sep	week5	Tuesday	Dry	AC9	y	y		94	2	1	0	0	0	97
25-sep	week5	Tuesday	Dry	AO5	y	y	6							6
27-sep	week5	Thursday	Dry	AC1	y	y		24	2	0	3	0	0	29
27-sep	week5	Thursday	Rain	AC3	y	y		266	23	4	5	0	0	298
27-sep	week5	Thursday	Dry	AC4	y	y		595	19	0	4	0	0	618
27-sep	week5	Thursday	Rain	AC7	y	y		20	5	3	0	0	0	28
27-sep	week5	Thursday	Dry	AC8	y	y		180	14	2	1	0	3	200
27-sep	week5	Thursday	Dry	AC9	y	y		167	6	0	0	0	0	173

27-sep	week5	Thursday	Rain	AO5	y	y		54	14	0	0	3	0	71
28-sep	week5	Friday	Dry	AC1	y	y		36	3	0	0	0	0	39
28-sep	week5	Friday	Dry	AC3	y	y		220	12	8	8	0	1	249
28-sep	week5	Friday	Dry	AC4	y	y		409	32	2	2	0	0	445
28-sep	week5	Friday	Dry	AC7	y	y		28	1	0	0	0	0	29
28-sep	week5	Friday	Dry	AC8	y	y		115	21	0	0	0	0	136
28-sep	week5	Friday	Dry	AC9	y	y		210	5	0	1	0	0	216
28-sep	week5	Friday	Dry	AO5	y	y		34	2	15	1	0	0	52
29-sep	week5	Saturday	Dry	AC1	y	y	9							9
29-sep	week5	Saturday	Dry	AC3	y	y		145	8	1	0	0	0	154
29-sep	week5	Saturday	Dry	AC4	y	y		424	15	0	2	0	0	441
29-sep	week5	Saturday	Dry	AC7	y	y		16	0	0	0	0	0	16
29-sep	week5	Saturday	Dry	AC8	y	y		89	10	0	0	0	0	99
29-sep	week5	Saturday	Dry	AC9	y	y		112	8	0	0	0	0	120
29-sep	week5	Saturday	Dry	AO5	y	y		13	2	0	3	0	0	18
3-okt	week6	Wednesday	Dry	AC1	y	y	5							5
3-okt	week6	Wednesday	Dry	AC3	y	y		94	11	0	0	0	0	105
3-okt	week6	Wednesday	Dry	AC4	y	y	6							6
3-okt	week6	Wednesday	Dry	AC7	y	y		102	21	0	0	0	0	123
3-okt	week6	Wednesday	Dry	AC8	y	y		11	8	14	13	20	0	66
3-okt	week6	Wednesday	Dry	AC9	y	y		24	2	5	2	1	0	34
3-okt	week6	Wednesday	Dry	AO5	n	n								0
4-okt	week6	Thursday	Rain	AC1	y	y	8							8
4-okt	week6	Thursday	Rain	AC3	y	y		109	21	5	6	0	0	141
4-okt	week6	Thursday	Rain	AC4	y	y		14	0	0	1	0	0	15
4-okt	week6	Thursday	Rain	AC7	y	y		59	1	0	0	0	0	60
4-okt	week6	Thursday	Rain	AC8	y	y		60	2	0	0	0	0	62
4-okt	week6	Thursday	Rain	AC9	y	y		55	2	5	2	1	0	65
4-okt	week6	Thursday	Rain	AO5	n	n								0
6-okt	week6	Saturday	Dry	AC1	y	y		50	11	0	0	0	0	61
6-okt	week6	Saturday	Dry	AC3	y	y		120	0	1	1	0	0	122
6-okt	week6	Saturday	Dry	AC4	y	y		120	3	0	5		0	128
6-okt	week6	Saturday	Dry	AC7	y	y		230	9	0	0	0	0	239

6-okt	week6	Saturday	Dry	AC8	y	y		47	0	0	0	0	0	47
6-okt	week6	Saturday	Dry	AC9	y	y		50	0	0	0	0	0	50
6-okt	week6	Saturday	Dry	AO5	n	n								0
7-okt	week6	Sunday	Rain	AC1	y	y		51	2	0	1	0	0	54
7-okt	week6	Sunday	Rain	AC3	y	y		230	0	1	1	0	0	232
7-okt	week6	Sunday	Rain	AC4	y	y		401	1	0	0	0	0	402
7-okt	week6	Sunday	Rain	AC7	y	y		376	29	0	0	0	0	405
7-okt	week6	Sunday	Rain	AC8	y	y		110	0	0	0	0	0	110
7-okt	week6	Sunday	Rain	AC9	y	y		95	0	1	0	0	0	96
7-okt	week6	Sunday	Rain	AO5	n	n								0
9-okt	week7	Tuesday	Dry	AC1	y	y		79	1	11	0	0	0	91
9-okt	week7	Tuesday	Dry	AC3	y	y		826	2	1	1	0	0	830
9-okt	week7	Tuesday	Dry	AC4	y	y		580	3	0	0	0	0	583
9-okt	week7	Tuesday	Dry	AC7	y	y		806	4	0	0	0	0	810
9-okt	week7	Tuesday	Dry	AC8	y	y		78	0	0	0	0	0	78
9-okt	week7	Tuesday	Dry	AC9	y	y	2							2
9-okt	week7	Tuesday	Dry	AO5	n	n								0
11-okt	week7	Thursday	Rain	AC1	y	y		79	1	11	0	0	0	91
11-okt	week7	Thursday	Rain	AC3	y	y		730	2	1	1	0	0	734
11-okt	week7	Thursday	Rain	AC4	y	y		307	3	0	0	0	0	310
11-okt	week7	Thursday	Rain	AC7	y	y		828	4	0	0	0	0	832
11-okt	week7	Thursday	Rain	AC8	y	y		128	0	0	0	0	0	128
11-okt	week7	Thursday	Rain	AC9	y	y		120	6	0	0	0	0	126
11-okt	week7	Thursday	Rain	AO5	n	n								0
12-okt	week7	Friday	Rain	AC1	y	y		54	0	0	0	0	0	54
12-okt	week7	Friday	Rain	AC3	y	y		97	2	0	0	0	0	99
12-okt	week7	Friday	Rain	AC4	y	y		230	9	0	0	0	0	239
12-okt	week7	Friday	Rain	AC7	y	y		210	2	0	1	0	0	213
12-okt	week7	Friday	Rain	AC8	y	y		239	0	2	0	0	0	241
12-okt	week7	Friday	Rain	AC9	y	y		251	3	0	0	0	0	254
12-okt	week7	Friday	Rain	AO5	n	n								0
14-okt	week7	Sunday	Dry	AC1	n	y								0
14-	week7	Sunday	Dry	AC3	y	y		361	2	0	0	0	0	363

okt														
14-okt	week7	Sunday	Dry	AC4	y	y		46	0	0	7	0	0	53
14-okt	week7	Sunday	Dry	AC7	y	y		220	8	0	3	0	0	231
14-okt	week7	Sunday	Dry	AC8	y	y		95	0	2	0	0	0	97
14-okt	week7	Sunday	Dry	AC9	y	y		190	3	0	0	0	0	193
14-okt	week7	Sunday	Dry	AO5	n	n								0