Investigating the Impacts of the Clearing of Primary Rainforest on the Foraging Distribution of *Atta cephalotes*

Jeremy Liberman

Corresponding emails: libermanj02@gmail.com & info@sustainableamazon.org

Abstract

Leaf-cutting ants of the tribe Attini are among the most prolific of all neotropical herbivores, harvesting immense quantities of vegetation and thereby influencing plant communities and overall forest structure. Unlike many other similar ecosystem engineers, leaf-cutting ants of the genera *Atta* and *Acromyrmex* are believed to profit from human induced disturbances. At the study site, Finca Las Piedras, in the Peruvian Amazon, a colony of *Atta cephalotes* was located in close proximity to a recently deforested area, and was monitored over the course of approximately one month to determine if the ants would expand their foraging trails into the cleared area or restrict foraging to the intact forest. All foraging trails leading out from the central nest location were tracked and monitored daily to assess traffic, average worker size, average load of vegetation carried by individual workers, and frequency of load-laden workers carrying additional minimae as hitchhikers. Only 4 of the 9 located foraging trails entered the deforested area, and these did not appear to show linear trends with regards to increasing or decreasing traffic after entering this area. However, these trails did appear to be generally more trafficked than trails which never entered the cleared area. Additionally, workers were observed harvesting novel items, such as flower petals of *Symphonia globulifera* and unidentified fungal bodies. They were also observed excavating at several locations for short periods of time, and these novel behaviours warrant further study.

Introduction

Neotropical rainforests, specifically within the Amazon basin, are among the most biodiverse terrestrial habitats known to science, with the Madre de Dios region of Peru being cited as having the richest diversity of fauna of any terrestrial region on Earth (Forsyth & Miyata, 1987). In the Madre de Dios Department of the Peruvian Amazon, the habitat remains mostly undisturbed as primary growth lowland rainforest and is largely understudied. While this region, along with the northwestern Brazilian Amazon, has remained mostly intact, it has become the site of recent intensive logging since the year 2000 (Asner et al., 2009). This has likely in part resulted from road expansion in Manu National Park and the Amarakaeri Communal Reserve, along with illegal gold mining and logging operations in the area (Gallice et al., 2017).

Located in the heart of this region, the Finca Las Piedras biological station hosts approximately 52 hectares of mostly mature Terra Firme rainforest, surrounded by Brazil Nut concessions allocated by the Peruvian government. While much of the surrounding property is used to grow and harvest Brazil Nut (*Bertholletia excelsa*) trees, there are also many monocultures of corn, papaya, and soybeans. Many of these crops require the complete deforestation of the rainforest habitat, often in several stages. In 2024, a neighbouring property to Finca Las Piedras, which had previously hosted a few corn monocultures, suffered a second crop failure, and the land use on the property began to change. In May of 2024, a strip of land along the northern border of Finca Las Piedras was cleared of the primary growth forest understory, possibly to allow for the creation of monocultures It is likely that such deforestation will exhibit dramatic ecosystem-wide effects (Asner et al., 2009).

Leaf-cutting ants of the tribe Attini (Hymenoptera: *Formicidae*) are among the most prolific herbivores in the Amazon basin, accounting for massive amounts of vegetative consumption. These ants are known as ecosystem engineers, and their herbivory and non-trophic activity can alter the successional trajectory of plant species and the species composition in the surrounding area (Leal et al., 2014). After harvesting leaf fragments from the surrounding vegetation, leaf-cutting ants use these fragments to build a substrate upon which to grow a fungal symbiont *(Leucocoprinus gongylophorus*), which the ants in turn rely upon for food. This stable source of nutrition has allowed Attini ants to become among the most successful ants in the neotropics, being found from Mexico south into Argentina (Hogsdon, 1955).

The response of leaf-cutting ants to human disturbance is relatively understudied, with various conflicting accounts in the literature. Many species have been known to thrive in human disturbed areas, with *Atta colombica* reported to utilize unpaved roads for their foraging trails (Winston & Herz, 2015). The nest density of many *Atta* and *Acromyrmex* species has been shown to increase after the clearing of mature rainforest, and decline with the growth of secondary forest (Vasconcelos & Cherrett, 2008). Active colonies of *Atta sexdens, Atta laevigata*, and *Atta opaciceps* all seem to proliferate in disturbed areas along roadsides (Siqueira et al., 2017). However, when tree canopy removal allows direct sun exposure on nests of *Atta sexdens*, many nests become inactive or relocate to intact forest (Van Gillis and Vanderwoude, 2012). *Atta cephalotes*, as opposed to many other *Atta* species, is more abundant in habitats of the forest interior, and is believed to be more strongly associated with undisturbed woodland environments (Urba et al., 2007). However, the herbivory rate of *Atta cephalotes* was found to be increased along edge habitats, and it is believed that they prefer to harvest pioneer species for their nutritional value and lowered defences (Urba et al., 2007).

To examine the effects of such deforestation, I plan to study the leaf-cutting ants along the “Cortahojas” trail at the Finca Las Piedras biological station. These ants are all members of the species *Atta cephalotes*, which constructs discrete nest sites cleared of vegetation with many surrounding foraging trails. The colony of leaf-cutting ants in this area is located very close to the border of the property, and the forest across the border in the neighbouring property was clear cut approximately one month before the time of study. Therefore, the leaf-cutting ants in this this location are directly exposed to both a clear cut and mature Terra Firme rainforest on different sides of the border, demarcated by the “Lindero” trail, and have the opportunity to colonize the newly cleared area or restrict foraging to the old growth rainforest.

Methods

To examine how the behaviour of this colony of leaf-cutting ants is affected by such a human disturbance, all foraging trails leading out of the nest site were tracked and monitored over the course of approximately one month (28 days). The perimeter of the nest site was searched for any foraging trails with at least one ant passing along in either direction (outbound and inbound from the nest) per minute. These foraging trails were mapped using GPS Tracks version 4.5.7 to map beginning and end points, to determine the location of the source of vegetation that the leaf cutting-ants are harvesting, and whether it was on the disturbed or undisturbed side of the border. The perimeter and the nest entrances from which the ants started their foraging trails were mapped using measuring tape and a compass to determine the length and angle of their constituent vectors. If the cleared forest allowed for the leaf-cutting ants to colonize the area and find new sources of vegetation, the trails would lead to sources on the opposite side of the border in the cleared area. The foraging trails were monitored for changes to determine whether, over time, the ants begin to harvest more vegetation from within the cleared forest, indicating their ability to colonize the area.

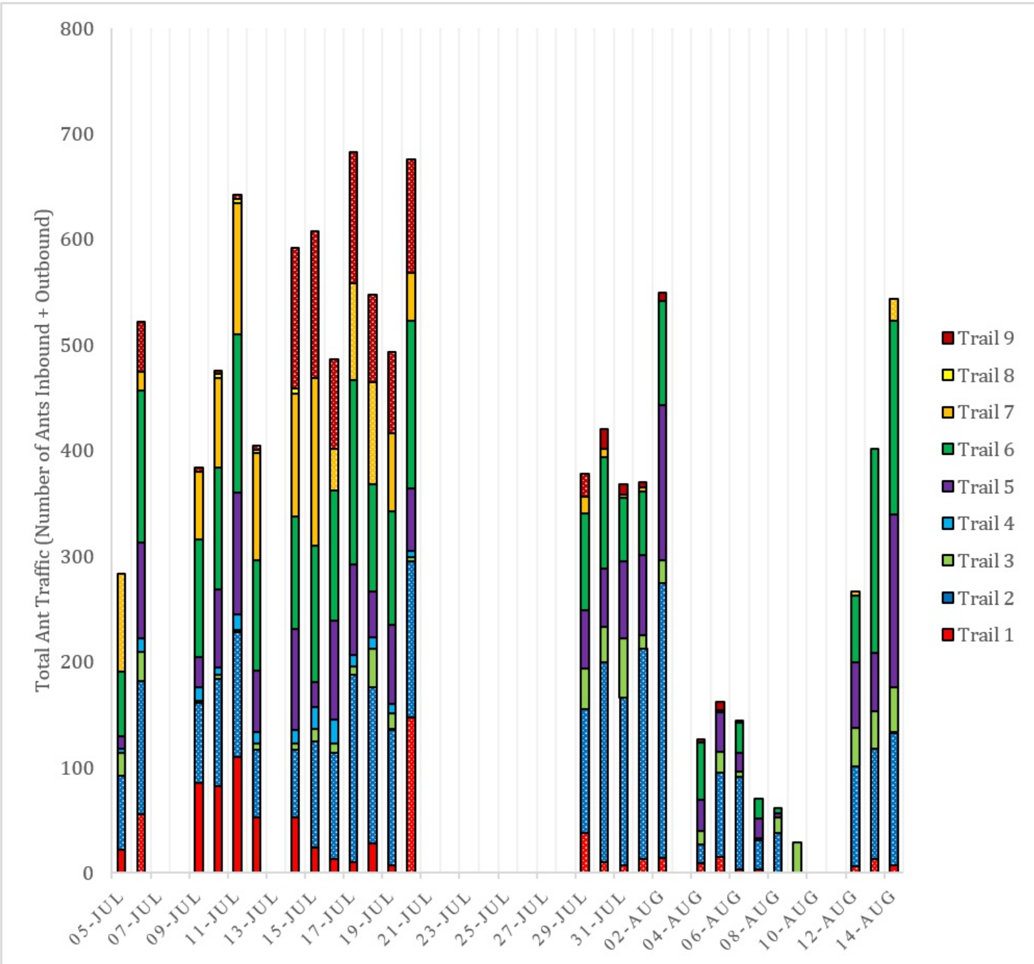
There were five parameters used to measure the foraging behaviour of the leaf-cutting ants, and monitor changes over time. The first is traffic along foraging trials, which would be measured through counting the number of ants passing through a certain point along their foraging trails during a one-minute window. A clearly marked waypoint will be located along all the foraging trails, and all ants that pass through this waypoint over the course of one minute will be recorded. The ants will be recorded as either outbound (leaving the nest) or inbound (approaching the nest) to determine the number of outbound or inbound ants along the waypoint per minute. The number of ants proceeding outbound or inbound will be recorded during separate one-minute intervals, so as to not confuse the number of ants proceeding in each direction. These two measurements, taken together, can be used as a proxy for overall density along the foraging trails. Another one-minute window was used to track the frequency of workers carrying leaves or a load of any kind inbound toward the nest. During this one minute period the frequency hitchhiking behaviour was also measured (minimae riding on the leaf-fragments carried by larger workers) by counting the number of laden inbound workers also carrying hitchhikers. The hitchhikers are believed to defend against parasitic phorid flies (Yackulic & Lewis, 2007), and the proportion of foragers laden with leaves that also carry minimae as hitchhikers can thus be used to indicate the threat of parasitism along the trail, and whether it is affected by deforestation.

As soon as this minute finished, the first ant to pass through the waypoint again was sampled, and a micrometre was used to the measure the head width of the sampled specimen. This can be used to track the distribution of worker sizes along the foraging trails, as larger workers are used to carry larger leaf fragments, indicating a greater rate of harvest. Large workers and soldiers along the trail may also suggest an attacking trail, to eliminate a threat to the colony or reinforce the colony’s defences. In addition, for the first worker carrying a leaf fragment which passed through the waypoint, the fragment was sampled and its length measured (the greatest observable length from one end of the leaf fragment to the other). This can also be used to indicate the rate of harvest, as larger leaf fragments will be carried when the source is harvested more heavily. Each of these five parameters was measured along each foraging trail, each day of study, and the order of the foraging trails monitored was changed each day to ensure that the order in which the trails are sampled (and thus the effect of temporal distribution) does not significantly affect the observed results.

Results

Of the nine foraging trails located from the central leaf-cutting ant nest, only four ever ventured into the cleared area: Trails 1, 2, 7 and 9. Trail 2 had already entered the cleared area by the time of study, and remained extended into the cleared area for the remainder of the study period. Not all trails were monitored each day, but the first date that the trails were recorded to have entered the cleared area was assumed to be the first date that the trail entered the cleared area. Based upon this assumption (which may not be entirely accurate), the traffic on trails 1, 7, and 9 all increased upon entering the cleared area. For trail 1, the average traffic recorded after entering the cleared area was approximately twice as low as the average traffic recorded when it had not entered the cleared area (Figure 1), though the highest traffic recorded when it had entered the cleared area was approximately 134% higher than before it had entered the cleared area (Figure 1). This high traffic was followed by a week-long absence of data due to a break in the study period, but it is possible that the traffic remained high during this break and decreased when the study resumed afterwards. For trail 7, the average traffic recorded after entering the cleared

Figure 1: Daily foraging traffic at each foraging trail. All detectable foraging trails were measured each day of study during a period of approximately 3-4 hours starting at 10:00 AM or 2:00 PM. Dotted bars signify when the indicated foraging trail was recorded to have ventured into the cleared area.



area was approximately 16% higher than the average traffic having not entered the cleared area (Figure 1), though the highest traffic recorded when it had entered the cleared area was approximately 40% lower than when it had not entered the cleared area (Figure 1). Trail 7 was only recorded to have entered the cleared area for five days, though the true number may have been much higher. For trail 9, the average traffic recorded after entering the cleared area was more than seven times higher than the average traffic having not entered the cleared area (Figure 1), and the highest traffic when it had entered the cleared area was also approximately seven times higher than the highest traffic after it had entered the cleared area (Figure 1). Trail 9 was also the most closely located to the cleared area at its origin. Trail 2, which entered the cleared area throughout the duration of the study, was on average the most trafficked of all the foraging trails recorded (Figure 1), and reached the highest peak in traffic, approximately 50% higher than the second highest peak in traffic on trail 6.

Discussion

Overall trends were difficult to discern with regards to whether traffic increased after trails entered the cleared area or not. Many trails which entered the cleared area showed trends that did not differ in any discernible way from the trails which did not enter the cleared area, and trails that entered the cleared area did not exhibit similar overall trends after entering the cleared area. Because the clearing did not appear to present differences in the traffic of the leafcutter ant foraging trails and their direction, the conclusions met in previous studies (Urbas et al., 2007; Vasconcelos et al., 2008; Siquiera et al., 2017) suggesting that leafcutter ants profit from human disturbance was not supported by the data in this study. The leafcutter ants did utilize man-made hiking trails as foraging trails, in a similar fashion to the utilization of unpaved roads (Winston & Herz, 2015), but did not fully utilize the man-made path located closest to the nest. However, because the data was only collected approximately a month after the initial clearing in proximity to the nest, no baseline data existed prior to the clearing, and so no comparison in the traffic of the foraging trails can be established. Moreover, this was one specific colony of *Atta cephalotes*, and may exhibit a different response to the clearing than other colonies.

This particular colony of leafcutter ants was also observed exhibiting several novel behaviours. Many of the ants appeared to be harvesting the petals of the *Symphonia globulifera* (*Clusiaceae*) flower, even more commonly than they appeared to be harvesting leaves. This may have possibly been due to specific chemicals inside these petals, though many of the commonly known antimicrobial properties of the plant are known to be derived from its leaves. The colony also appeared to harvest yellow fungal bodies of an unidentified species, and the reasons for this are also unknown. Additionally, workers of this colony were almost never members of the soldier caste (with head widths above 3 mm), with only 3 soldiers being identified throughout the period of study. Several times workers were observed in large aggregations grasping the soil with their mandibles in small, cleared areas, appearing to excavate a subterranean network. Whether they were attempting to move the location of their nest was unknown and all known instances of excavation disappeared after several days. These large aggregations coincided with extremely high traffic on the trails leading to these sites, with many workers being recruited in a specific area. The biology behind the behaviours of this particular colony requires further study.

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