

Climbers Growing in a *Mauritia flexuosa* Dominated Palm Swamp and Their Importance in Succession After Disturbance at Finca Las Piedras in Madre De Dios, Peru

Assata Golash^{1, 2}

¹ Department of Natural Resources, California Polytechnic State University, San Luis Obispo, CA, USA

² Alliance for a Sustainable Amazon (ASA), Las Piedras, Madre de Dios, Peru

Corresponding emails: agolash@calpoly.edu & info@sustainableamazon.org

Abstract

Aguajales are peatland palm swamps dominated by *Mauritia flexuosa* (Aguaje palm) and are considered important carbon storages in the Neotropics. Aguajales are important Amazonian ecosystems because they are a carbon sink, a habitat for many plants and animals, and are economically important since the Aguaje fruit is commonly sold in regional markets. These peatlands are also valuable to researchers for palaeoecological records because of the peat formation process. Lianas and vines are very common throughout many tropical regions but have often been considered a pest from research and logging perspectives. Previous literature has only characterized lianas as being harmful to trees, as they limit growth and light access. However, a recent study found that lianas are quite beneficial to forested areas especially after natural or anthropogenic disturbances because they protect the dominant species while they are regenerating. In this study, I surveyed for lines and vines in Aguaje palms located in the edge of a disturbed forest with the objective to know their diversity, as well as their distribution related to the edge. I found a relationship between the distance an Aguaje palm is from the disturbed edge and the number of climbers that will be growing on it, where the highest number of climbers were mostly located in the intermediate zone. These findings suggest that climbers might have a protective purpose within the Aguajal. Additionally, thanks to the inventory conducted, a field guide of fourteen morphospecies of climbers growing on the Aguaje palms was created. Classifying species in the Aguajal is one of the first steps in understanding the “liana threshold” in which lianas are beneficial or detrimental to a forested area. This is a preliminary study for the understanding of the importance of lianas and vines, particularly in Aguajal biological communities of Southern Peru.

Introduction

Mauritia flexuosa (aguaje palm) dominated peatlands of the Amazon region, referred to as Aguajales in Peru, are understudied. The few studies done, have exposed the great importance of these communities in carbon sequestration and their implications for the mounting issue of climate change (Householder et al., 2012). *Mauritia flexuosa* is important in these biological

communities as they have extensive root systems and large fans for leaves which routinely drop, as new leaves grow (Householder et al., 2012). The soils of Aguajales are often waterlogged, creating an anoxic environment, which in combination with the large amounts of organic matter falling from the Aguaje palms, creates the perfect environment for thick peat production

(Householder et al., 2012). Hence, the sum of these communities throughout the region produces a massive carbon sink. Recent studies have estimated there to be ten times as much peatland in the Amazon as previous estimates, displaying the growing understanding of their importance and exposing the absence of studies done on them (Householder et al., 2012). Additionally, the rapid pace of the peat formation allows for well-preserved palaeoecological records, which are helpful for understanding forest change in response to climate change (Roucoux et al., 2013).

Aguajales support flora adapted to frequently waterlogged, highly acidic, nutrient-poor, and seasonally variable conditions (Roucoux et al., 2013). Aguajales can be solely dominated by *Mauritia flexuosa*. In Peru, *Mauritia flexuosa* is important both economically and ecologically (Smith, 2015). The Aguaje fruit is considered one of the most important fruits in terms of income and nutrition in the Madre de Dios region (Smith, 2015). Over two dozen uses have been recorded for the palm, including the petioles being used to weave baskets, mats, clothing, etc. (Smith, 2015).

Vines and lianas can have large effects on canopy trees, particularly in tropical forests. They are often so successful because of their vast root systems and lack of need for structural integrity, so they can access both water and light by growing on large trees (Schnitzer, 2005). However, in Aguajales water is plentiful and palms have success expelling vines. Vines and lianas may not be able to compete as well with the trees in Aguajales, compared to the forest. Palms have thick trunks that are difficult for vines to attach to (Rich et al., 1987). Palms lack branches, which prevents lianas and vines from spreading throughout the canopy (Rich et

al., 1987). The continuous falling and regeneration of new fan leaves can pull vines down to the ground, preventing them from overtaking the access to light in the canopy (Rich et al., 1987).

There have been multiple studies displaying the impacts of vines and lianas on individual trees, however Marshall et al. argues that these studies may be bias and missing an aspect of the ecological system, which is generating these results (2020). Lianas are often very prevalent after disturbance but will fall in abundance as dominant tree species regenerate. Liana studies are typically less than five years long and may not account for recovery after a disturbance (Marshall et al., 2020). Lianas are an important part of succession after disturbance and may persist for thirty to seventy years before declining while the other dominant species develop (Marshall et al., 2020). Abundance of lianas is correlated to a reduction in tree growth, light gap regeneration, carbon sequestration, and water budgets (Schnitzer, 2005). However, forest-wide impacts on biodiversity, nutrient cycles, and productivity that lianas may provide have not been extensively studied, leaving climbers' relevance in forests largely unknown. Marshall et al. describes lianas to create a "bandage effect" in which they are helpful in protection after disturbance, but still allow for regeneration of dominant and understory species. However, if there is an abundance of lianas past the "liana threshold," it can create a positive feedback loop that could harm the forest by reducing biodiversity and dominant tree keystone species due to excessive liana growth. Marshall et al. claims their 2020 study to be the first of its kind on this phenomenon of a "liana threshold." It is a hope that this study will result in a reconsideration of

the negative view of lianas and encourage further studies on their potential importance. The “bandage effect” of lianas produces enhanced soil, seed diversity, and fauna and protection against fire, lightning, wind, weeds, and herbivory while the dominant forest species are recovering (Marshall et al., 2020). The hindering of tree growth by lianas may be beneficial after a disturbance, as it allows ample time for trees and understory species to develop structural and community complexity and avoid permanent damage to the area (Marshall et al., 2020).

Peatlands of Amazonia are vastly unexplored. Modern Amazonian forests are human-dominated environments to some extent, representing a threat for the natural dynamics of plant and animal communities overall, but particularly in habitats with hydric resources such as streams, lakes, ponds, and swamps where humans settle to live and work. Understanding the diversity and ecological interactions in aquatic environments, such as Aguajales, become urgent in the face of deforestation, fragmentation, and climate change. There are also few studies about the benefits of vines and lianas to ecosystems, as they are often viewed as a pest from many forestry and botanical perspectives. Hence, this study aims to provide an inventory of the vines and lianas growing on *Mauritia flexuosa* at Finca Las Piedras, a field station located at the edge of Terra-firme Forest in a non-protected area. The station encompasses the edge of a continuous forest composed of Brazil nut concessions and selectively logged forests on one side, and agricultural fields and cattle pastures on the other. This location allows sampling to a vital habitat amid its disappearance.

It is important to understand the composition of Aguajales to promote their protection. Aguajales are important Amazonian ecosystems because they are a carbon sink, a habitat for many plants and animals, and are very economically important since the Aguaje fruit is commonly sold in local markets. These peatlands are also very valuable to researchers as they can be used to understand changes in these regions over time through the peat formation process. The identification and record of species in the entire Amazon is also important as it can display how the region is changing over time. Classification of species forms a better understanding of the biological systems, which is important for conservation and management practices. The Amazon, being one of the largest carbon sinks and oxygen sources on the globe, is certainly important to conserve.

This inventory of vine and liana species growing on *Mauritia flexuosa* will serve as a guide to future researchers who wish to understand what the conditions of the area were and what organisms existed. Liana inventories are also important as they can be used to determine “liana thresholds” for different forest types, and hence be useful in understanding forest recovery after a disruption (Marshall et al., 2020). Research is needed to understand “liana thresholds” of different forest types to practice forest management that will be the best for regeneration. With continued forest degradation, understanding the importance of lianas in succession will be essential to conservation efforts.

My objective is to record and morphologically describe species of climbers in the Aguajal growing on *Mauritia flexuosa* at Finca Las Piedras and create a photographic field guide of morphospecies to be used by

future scientists in the station or those visiting Madre de Dios. I will also describe the climber species' abundance and distribution within the Aguajal and their association with previous disturbance and regeneration.

Methods

Data was collected in three distinct areas throughout the Aguajal at Finca Las Piedras. The first area was located in the interior of the Aguajal, where there is not much light. The second was in an intermediate area where the Aguajal is regenerating, there aren't many full-sized trees, and there was sunlight access throughout most of the tree at least on one side. The third area was directly next to a cattle field that was burned to clear vegetation. I surveyed every *Mauritia flexuosa* individual I walked past that was a minimum of 1.3m tall, not including leaves or petioles. I surveyed seven in the interior, five in the intermediate zone, and six next to the clear cut. At each Aguaje palm, I measured the DBH (diameter at breast height), determined the sex, and counted and described all the climber species growing only on that individual. Vines or lianas were included if they were growing on an Aguaje, had adventitious roots attached only to one Aguaje palm, and were at or higher than DBH. Plant species were identified to their botanical family and then morphospecies were described using distinguishing characteristics. Photos were taken of the leaf top and bottom, form, and any fruit or flower present so that a field guide could be created.

Statistical analyses were performed using Excel and R (R Core Team, 2014) and figures were produced using the package tidyverse (Wickham, 2019) and ggplot2 (Wickham, 2016) to display the species composition and abundance on trees in the

three respective zones and between Aguaje palm sexes. For count of individuals, a square root transformation was performed to meet ANOVA assumptions of normality. For Levine's test, variances were assumed to be equal among treatments and species count data to be normally distributed for the number of individual climbers on each Aguaje palm ($F=1.37$, $p=0.28$, n.s.). For the Shapiro test, climber count data was normally distributed ($W=0.88$, $p=0.02$), hence, ANOVA assumptions were met for count of individual climbers. For species count, variances were assumed to be equal among treatments and species count data to be normally distributed for the number of morphospecies identified ($F=0.22$, $p=0.8$, n.s.) and species count data was normally distributed ($W=0.89$, $p=0.03$), therefore, ANOVA assumptions were met for species count. For sex of individuals, a square root transformation was performed to meet ANOVA assumptions of normality. All square root transformations were performed in Microsoft Excel.

Results

Diversity and abundance of climbers in the Aguajal is presented. A total of 61 individuals, representing 17 morphospecies of climbers were found inhabiting the Aguajal. A single Aguaje palm was observed to host a maximum of nine species and a maximum of fifteen individuals. 27% of Aguaje palms had zero climbers. Aguajes were surveyed in three distinct zones: interior, intermediate and edge.

An ANOVA test was conducted on the influence of location on the number of climbers on an Aguaje palm, the location treatment included interior, intermediate, and edge ($F_2, 15=11.74$, $p<0.01$). The highest average of

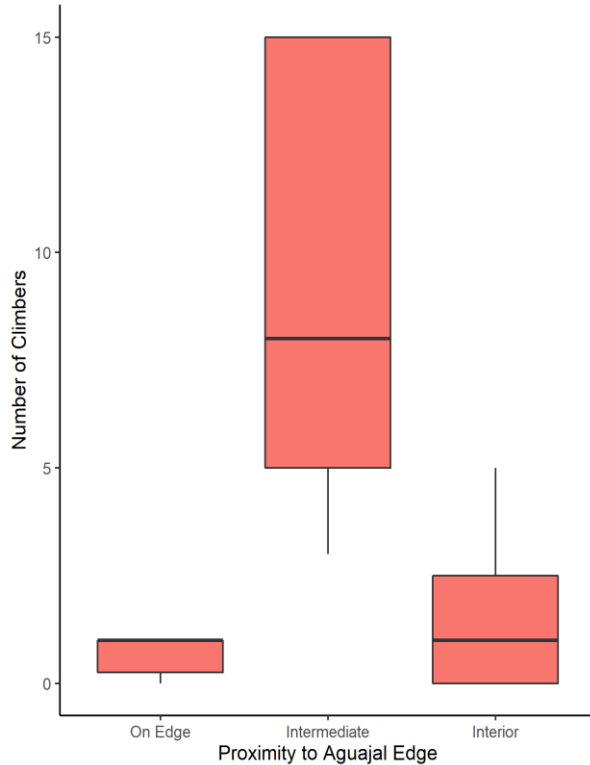


Figure 1: Number of climbers growing on a single Aguaje palm separated by proximity to the Aguajal edge.

individuals was found in the intermediate zone ($\bar{x}=9.2$, $sd=5.5$) and the lowest mean of individuals was found on the edge ($\bar{x}=0.7$, $sd=0.5$). Additionally, the location with the greatest mean of number of species was in the intermediate zone ($\bar{x}=5$, $sd=2.9$) and the lowest mean of species was in the edge zone as well ($\bar{x}=0.6$, $sd=0.5$).

The differences between number of individuals per location are statistically significant ($F_{2, 15}=11.74$, $p<0.01$). Regardless of the DBH of the Aguaje palms, location was still significant (interaction effects $F_{2, 12}=1.21$, $p=0.33$, n.s.). Tukey multiple comparisons of means resulted in intermediate-edge and interior-intermediate with significant differences ($p<0.01$ for both). The same pattern was found for the number of species per

location in the Aguajal when DBH was controlled for ($F_{2, 15}=11.77$, $p<0.001$). Interactions with DBH were tested and showed no significance ($F_{2, 12}=3.1$, $p=0.08$). The Tukey multiple comparisons of means resulted in intermediate-edge and interior-intermediate with significant differences ($p<0.01$ for both) for the number of species as well. The regressions between DBH and number of species and number of individuals show no significant association (see Appendix I and II).

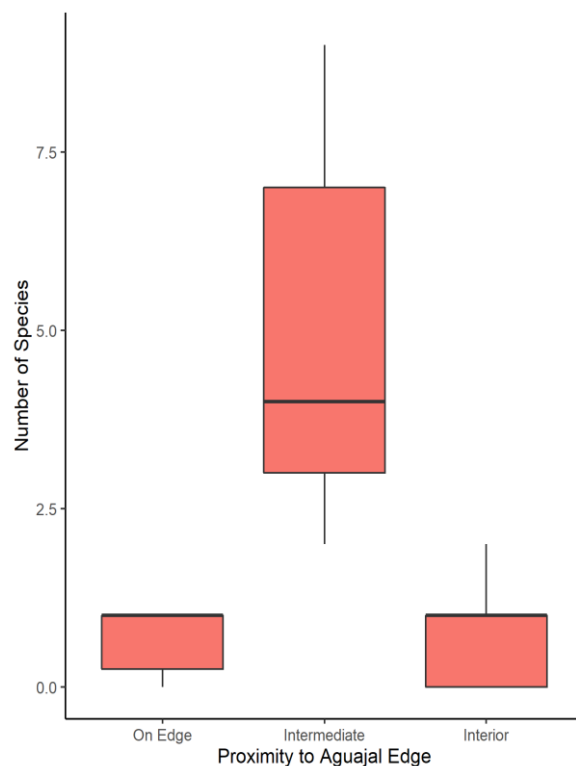


Figure 2: Number of climber species growing on a single Aguaje palm separated by proximity to the Aguajal edge.

Further analysis was conducted to compare number of species and number of individuals per sex of the palms and differences were significant for both. Male aguaje palms can host a significantly greater number of climbers, as well as a greater number of species, than female palms (Fig. 3 and 4).

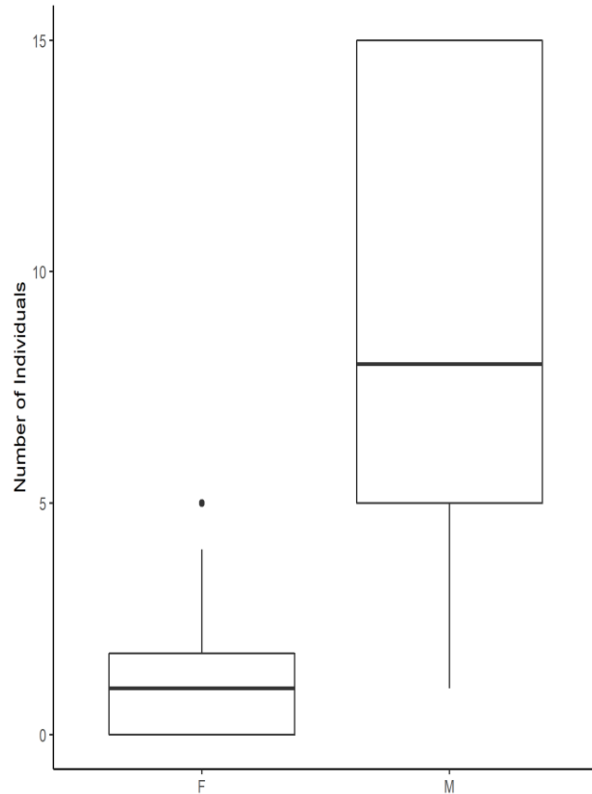


Figure 3: Number of individual climbers growing on a single male and female Aguaje palm.

Difference in number of individuals between female and male aguaje palms was significant (t-test, $t=-2.9$, $p=0.02$) and the same pattern was found for the number of species between male and female (t-test, $t=-3.1$, $p=0.01$).

Discussion

The Aguajal at Finca Las Piedras can be categorized as having seventeen distinguishable climber species and preliminary data shows that *Mauritia flexuosa* (Aguaje palm) individuals that are in the intermediate zone of the Aguajal have significantly more climbers growing on them than those that are in the interior of the Aguajal or right on the edge. The intermediate zone is defined as an area where the forest is

regenerating, so there are many smaller plants, but only a few trees standing. Hence, these few trees have lots of exposure to sunlight along their entire trunk, which is ideal for liana species growth.

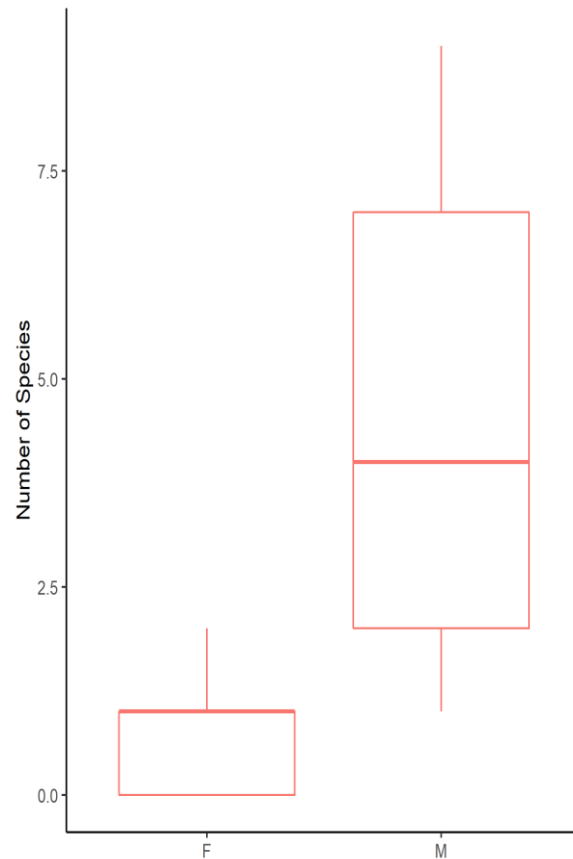


Figure 4: Number of climber species growing on a single male and female Aguaje palm.

It is believed that the Aguaje palms on the edge of the Aguajal had very few climbers because there may have not been enough time since the disturbance happened for the lianas to generate. The area on the edge is directly next to a cattle ranch that is a grass field, the area under the Aguaje palms was relatively bare of vegetation and the trees surveyed had fire scars from a relatively recent burn. Results examining the abundance of individual

climbers and species growing on Aguaje palms in the interior, intermediate, and edge zones of the Aguajal produced statistically significant results showing that the intermediate zone had the highest mean count of individual climbers and climber species, despite DBH. It is logical that the intermediate zone would have the most climbers because it has had ample time for the climbers to build up, there is enough sunlight for the climbers to be successful, and there is buildup of other understory plants surrounding the Aguaje palms, which is better for lianas in finding their host tree. Climber species will often grow towards the darkest place in hopes that they are finding the tallest tree to grow on, however, they also need access to light to successfully grow. The mid successional stages of a forested area after disturbance are therefore optimal growing conditions for climbers. These lianas are helpful to the regenerating area as they protect regenerating species from natural predators and destructive forces. In the undisturbed area of the Aguajal, the interior, there were very few climbers on the Aguaje palms, likely because of the darkness of the interior and that the large aguaje palms were able to outcompete the climber species.

Palms are especially successful at climber removal due to their thick bark, lack of branches, and constant expulsion and regeneration of fans. Liana abundance having an association with the edge of a forested area is consistent with previous studies (French et al., 2017). Marshall et al. also correlated liana abundance to land use intensity in fragmented forests (2020). Liana abundance is expected to increase for thirty to seventy years in a regenerating forest before declining, indicating that a very long-term study would be required of this Aguajal to understand its liana threshold and regeneration ability.

Results examining the abundance of individual climbers and species growing on male and female Aguaje palms also produced statistically significant results showing that males had the highest mean count of individual climbers and climber species. Further investigation and research should be conducted to understand the reasoning behind these results. Preliminary observations estimate that results could be related to female fruit production in attracting animals which may also feed on or harm liana species growing on the palm.

The results shown are very preliminary as only eighteen Aguaje palms were sampled. There may also be sampling bias as a systematic or systematically random process was not done for tree selection. In the study I went to three different areas in the Aguajal and selected the trees that were easily accessible to sample. Sampling Aguaje palms in the Aguajal was a challenge due to the flooding and inability to cross water and access many of the palms. In future studies I suggest a more standardized method to be used to determine the location of the palm or possibly measuring accessibility to light or other indicators of disruption as well. A more standardized method of Aguaje surveying should also be conducted to ensure more and better results.

Interestingly, lianas are most negatively associated with the biomass of large trees (Marshall et al., 2020). This asserts the great importance in protecting and regenerating old growth forests. In-tact forests will have the ability to naturally expel climber species and keep their populations under control. A reframing of the negative perception of lianas and other climber species is necessary in promoting positive forest regeneration. While lianas can be destructive and dominate when

their abundance is very high, they are also very important in protecting dominant species during forest succession after natural and anthropomorphic disturbances.

This study was done with a very short time frame and limited access to outside resources. However, the results ended up being significant and indicated much broader implications for forest and Aguajal regeneration. This growing field of research with the new perspective on liana species that Marshall et al. (2020) provided has important implications on conservation and forest management practices. Further research on the abundance of climbers growing in the Aguajal should be conducted to further understand their ecological role in forest health and succession.

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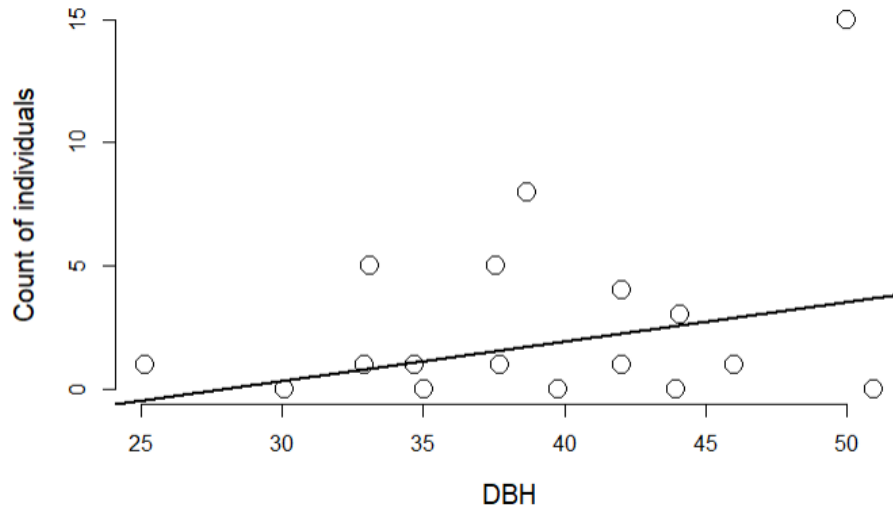
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Supplementary Material

Appendix I: Regression between DBH and number of climbers on an Aguaje palm represented in a scatter plot with a line of best fit ($R^2 = 0.1535$).



Supplementary Material

Appendix II: Regression between DBH and number of species on an Aguaje palm represented in a scatter plot with a line of best fit ($R^2 = 0.1646$).

