

Introduction

Cacao agroforestry systems have a great potential as a sustainable economic activity for smallholders that restores unprotected human-impacted forest areas (Vansynghel et. al., 2022), particularly in Colombia (Arenas et. al., 2023). The viability of this initiative is limited by low fruit set rates: there are several knowledge gaps of cacao's pollination networks (Toledo-Hernández et. al., 2017).

Research question

What is the effect of flower visitors in fruit set of cacao trees from a Colombian agroforestry system?

Materials & Methods

Study Site

The study was conducted at Granja Luker, a 22-hectare research center for cacao agroforestry systems in Santágueda, Caldas, Colombia. Located in the tropical dry forest of the Cauca River zombiome, the site experiences annual rainfall of 1,500 to 1,800 millimeters, mainly during two rainy seasons. The research focused on a single furrow in the clonal nursery with the ICS-1 auto-compatible clone.

Data Collection

Fieldwork was conducted from July 8th to 26th, 2024. Nine trees were observed, with 10 flower buds per tree labeled weekly and categorized into three groups: isolated, natural, and manual pollination. Cameras took flower photos every 10 seconds. Additionally, weather data was collected every 30 seconds.

Visitor collection took place on Tuesdays, Wednesdays, and Thursdays during sunrise, afternoon, and sunset, using a modified aspirator. Visitors were stored in 98% ethanol.

Data Analysis

Images of flower visitors (Figs. 5 & 6) will be analyzed using machine-learning software to determine visitation rates and identify visitor types. Pollen load analysis and DNA barcoding will be used to confirm the presence of cacao pollen and identify species at Pontificia Universidad Javeriana in Bogotá.

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Results

A total of 329 cacao flowers were observed, with 13.98% (46 flowers) setting fruit. However, only 1.21% (4 flowers) of these are still growing fruits one month after pollination. None of the isolated flowers set fruit, and manually pollinated flowers had more than double the fruit set of naturally pollinated flowers (Fig. 1). Fruit set rates ranged from 6.6% to 25% between individual trees, with those at the center of the furrow showing lower rates compared to those at the ends (Fig. 2)

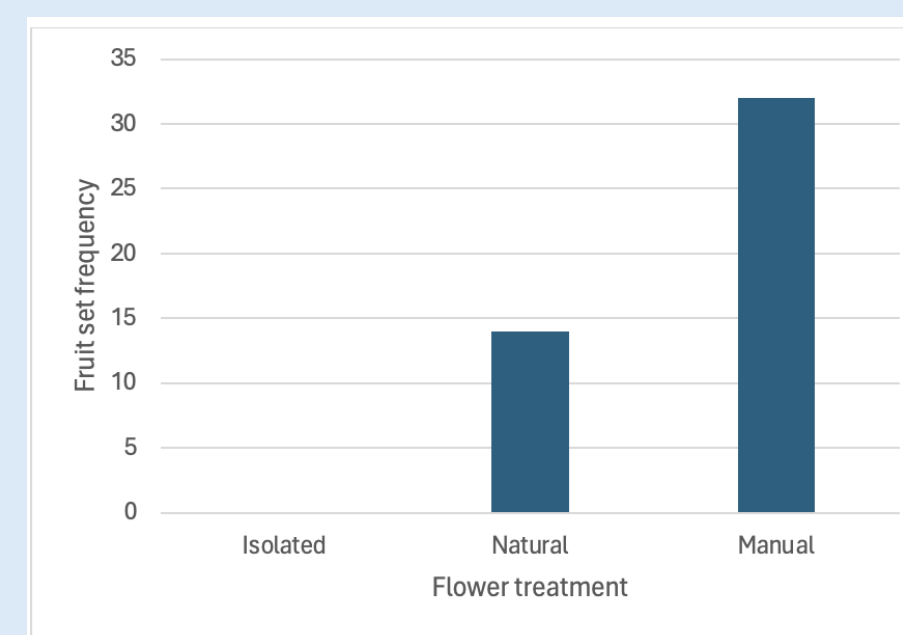


Figure 1. Frequency of fruit set in cacao trees per flower treatment for the entire observation period (July 8th to July 27th, 2024).

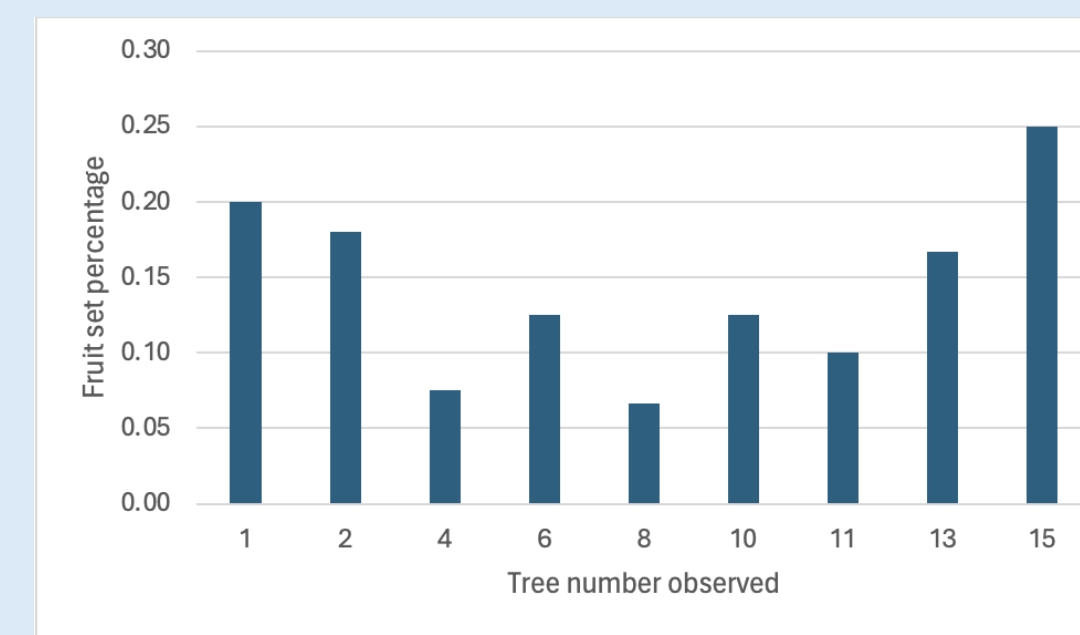


Figure 2. Percentage of fruit set among flowers of each observed cacao tree in the entire observation period (July 8th to July 27th, 2024).

During the observation period, 57 flower visitors were collected. The afternoon and sunset intervals had similar visitor frequencies, while the morning interval had significantly fewer visitors (Fig. 3). Most visitors were found on the staminodes of the flowers (Fig. 4). There was no clear pattern in visitor frequency among individual trees.

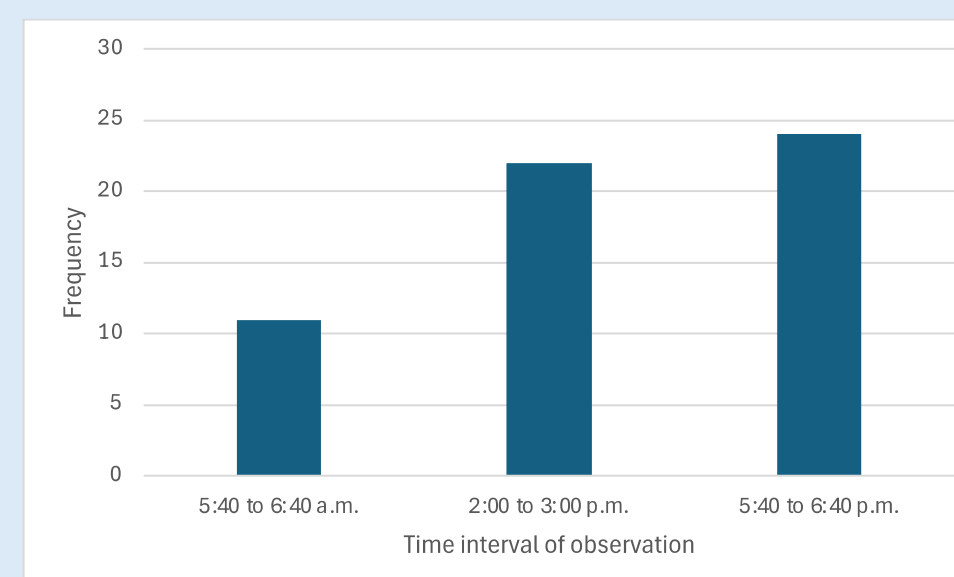


Figure 3. Frequency of collected flower visitors of cacao per time interval in the entire observation period (July 8th to July 27th, 2024).

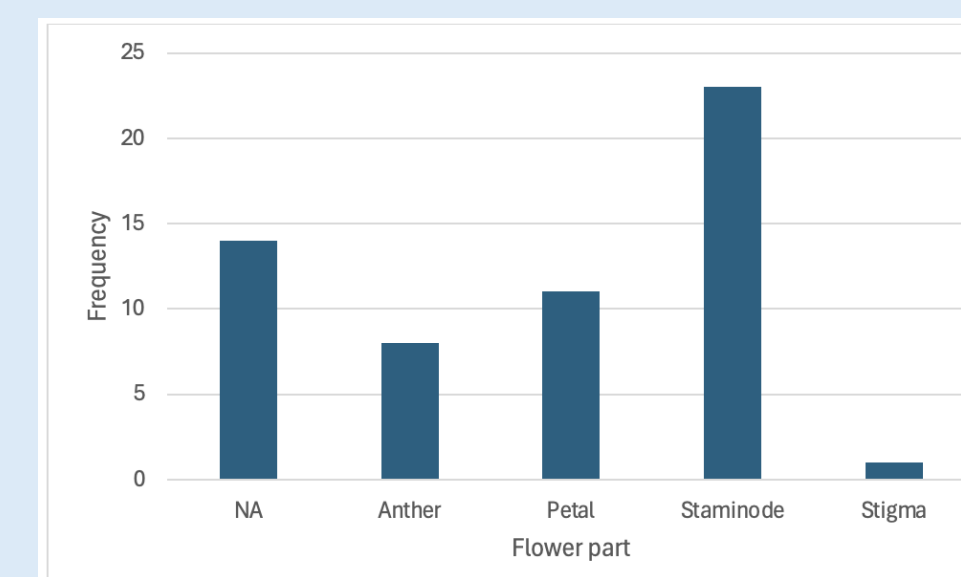


Figure 4. Frequency of collected flower visitors per flower parts at or near reproductive parts for the entire observation period (July 8th to July 27th, 2024). "NA" refers to instances where there was no record of the flower part in which the visitor was collected.

Discussion

- The study observed fruit set rates consistent with existing literature, showing a natural pollination rate of around 10% and increases with manual pollination (Jaramillo et. al., 2024). Patterns in fruit set are likely influenced by proximity to stingless bee colonies (Jaramillo et. al., 2024) and canopy cover (Toledo-Hernández et. al., 2017).
- Collected flower visitors align with known behavior in Ceratopogonidae flies (Jaramillo et. al., 2024), but their role in pollination requires further investigation (Vandromme et. al., 2023).
- Understanding the patterns of visitation patterns will allow the proposal of management strategies that increase pollination success.



Figure 5. Example of a day photo of a cacao flower taken with a Wingscapes TimelapseCam Pro at Granja Luker research centre.



Figure 6. Example of a night photo of a cacao flower taken with a GardePro TSCF camera at Granja Luker research centre.

References

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