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*Full Length Research Paper*

# Evaluation of the fruit-drop of *Myrciaria dubia* (H.B.K.) Mc Vaugh, camu-camu, in the "five River Basins" collection of the San Miguel experimental research station - IIAP, Loreto, Peru

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**This study presents preliminary findings regarding the factors that cause fruit-drop in a collection of camu-camu originating from natural stands in five different river systems in Loreto, Peru. We evaluate the percentage of fruits attacked by insect pests, the retention of flowers and fruit according to branch diameter, and the influence of rainfall and temperature on fruit-drop. With respect to factors related to genetics and plant origin, plants from the Putumayo River Basin have the lowest fruit-drop, greatest yield and average weight per fruit, and the lowest rate of attack by insect pests. During the reproductive period, which lasts twelve weeks, the critical phase in which the majority of flower and fruit-drop occurs is during the first seven weeks. The total retention of flowers through to mature harvestable fruit was 5.1% and on average only 25% of the formed fruit reached a mature harvestable state. Our results show that insect pests caused 9.27% of the fruit-drop; of these, *Edessa* sp. caused 98.7% of pest related fruit-drop and *Conotrachellus dubiae* caused 1.3%. Undetermined factors, potentially including hormonal, nutritional, and climatic (wind, rain, and temperature), caused the remaining 90.73% of fruit-drop. While higher environmental temperatures corresponded to higher fruit-drop, greater pluvial precipitation corresponded to lower levels of fruit-drop.**

**Key words:** *Myrciaria dubia*, fruit culture, camu-camugenetic, improvement, fruit-drop, physiology.

## INTRODUCTION

The fruit camu-camu (*Myrciaria dubia* Mc Vaugh H.B.K.) contains a high level of vitamin C between 877 and 3017 mg of total ascorbic acid/100 g of edible pulp (Pinedo et al., 2001; Yuyama, 2002).

In Peru, the natural populations of camu-camu *M. dubia* Mc. Vaugh (H.B.K) are found in the lowland rainforest of the Department of Loreto, particularly in the river basins of the Ucayali (specifically in the lake Cocha Sahua Supay), the Napo (in the lake Núñez cocha), the main branch of the Amazon (in El Charo and Yarapa lakes), and the Nanay (Flores, 1997).

Camu-Camu's high levels of Vitamin C along with its corresponding nutritional and metabolic functions led to its introduction to the Japanese market, and, between 2004 and 2007, a resulting increase in the exportation of camu-camu pulp (Pinedo, 2007).

The Organization of Ibero-American States estimates that Japan alone annually creates a demand for approximately 230 thousand metric tons of camu-camu, an amount that greatly exceeds Peruvian supply (INRENA, 2000).

An estimated 46% of *M.dubia* flowers are pollinated, and 15% of fruits are aborted before reaching maturity (Peters and Vásquez, 1986). Inga et al. (2001) found that only 27% of newly formed fruit reached a mature harvestable state. Little information exists regarding the

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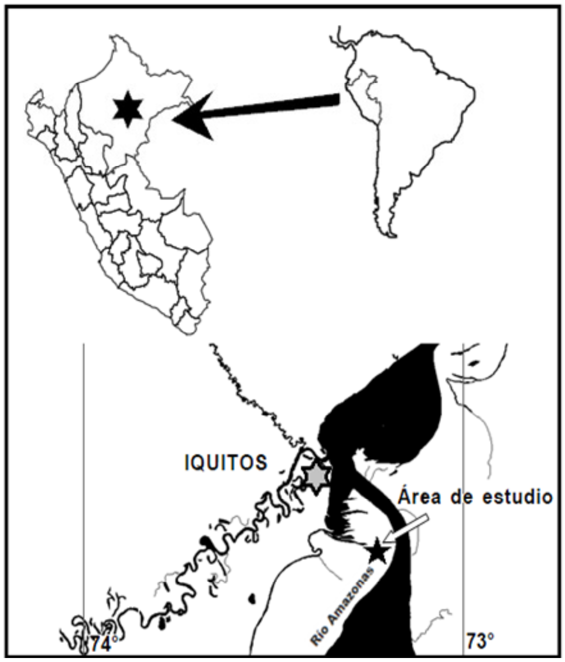



**Figure 1.** Study area location.

causes of fruit-drop in this species. The objective of this study was to investigate the reasons why fruit-drop occurs during the reproductive phase.

## MATERIALS and METHODS

This study was conducted in the "Cinco Cuencas" (Five River Basins) Collection of the San Miguel Experimental Research Station of the Instituto de Investigaciones de la Amazonía Peruana (Investigatory Institute of the Peruvian Amazon) located on the left bank of the Amazon River up river from the city of Iquitos, Peru (Figure 1).

The study collection includes 1200 plants that originated from five different tributaries of the Amazon River (the Itaya, Tigre, Napo, Curaray, and Putumayo).

Based on their phenological state, we selected and evaluated fruit-drop in 25 plants (five from each river). In each plant, we marked five branches from one to five in decreasing order according to each branch's diameter. Every seven days we counted the following parameters: number of floral buds, number of fruit not fallen, and number of fallen fruit.

In the fallen fruit that showed symptoms of attack or infestation by insect pests, each pest was classified using the identification key for damage to camu-camu fruits (Delgado and Couturier, 2004). Fruits and flowers were counted over the twelve-week reproductive phase. In this period, we counted: total production of flowers, number of immature and mature fruits per branch, and total number of fallen fruit per plant.

We used a split plot experimental design with the five treatments, or large parcels, represented by the plants from the different river basins, the five branches representing the sub-parcels, and five different plants randomly distributed throughout the study site providing five replications. Using the statistical packages SPSS and INFO-GEN, we calculated descriptive statistics, analysis of variance, and correlation statistics.

## RESULTS

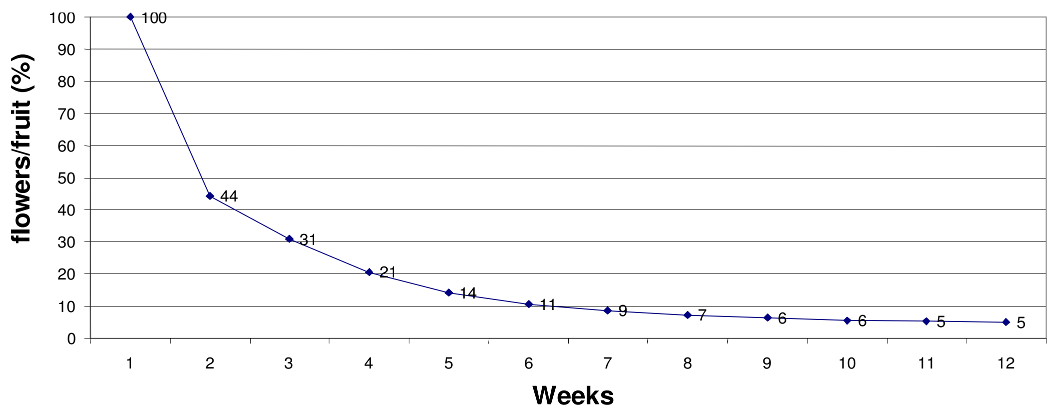
The critical phase, with the highest number of fallen flowers and fruits, occurred during the first seven weeks of the reproductive process. The greatest number of flowers fell during the first three weeks, and in the four following weeks, while the fruit were in a small green state, the largest number of fruit fell (Graph 1). Evaluation of the level of floral retention revealed that 5.1% of formed flowers and 25% of formed fruit survived to become mature harvestable fruits.

In regards to genetic factors, the individual plants originating from the Putumayo River Basin had the highest level of fruit retention (29.86%); those from the Curaray River Basin showed the lowest fruit retention (22.09%) (Graph 2). Branches with larger diameters maintained a greater percentage of their fruit (31.12%) (Tukey Test, $\alpha$=0.04).

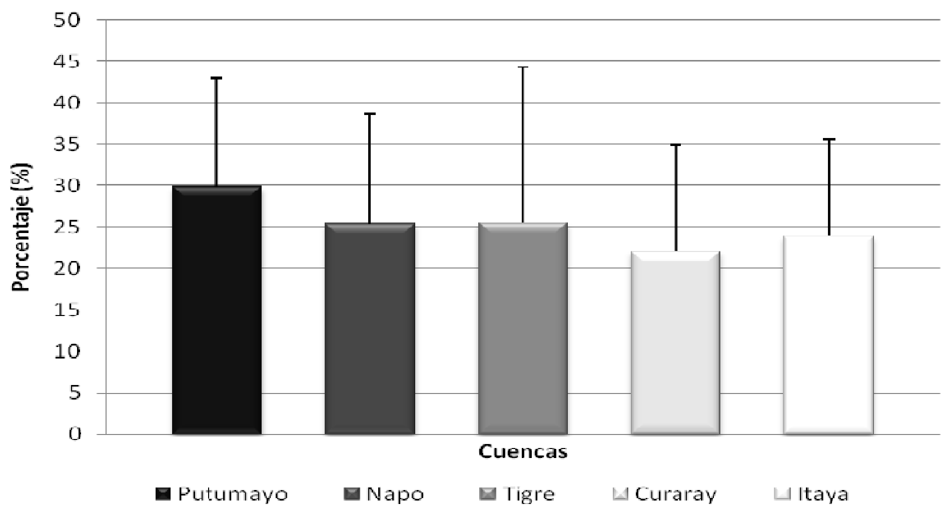
### Causes of fruit-drop

With respect to the fall of flowers and fruit, 90.73% did not show any symptoms of disease and their fall could be attributed to physiological-nutritional factors, which include the natural abscission of flowers and fruit during the first three weeks of the reproductive phase, and to various climatic factors (wind, rain, and temperature) (Graph 3).

The observed diseases caused 9.27% of fruit-drop; of these, the majorities (9.15%) were caused by the




**Graph 1.** Retention of camu-camu from flowers to mature fruit.




**Graph 2.** Fruit retention by river basin.

Heteroptera *Edessa* sp. and 0.12% by *Conotrachellus dubiae*. While plants that originated in the Putumayo River Basin had the lowest percentage of disease caused fruit-drop (5.51%), those from the Curaray River Basin had the highest level (11.78%).

In terms of climatic factors, on one hand, rainfall was inversely proportional to the amount of fruit-drop (Graph 4); on the other hand, temperature had a directly proportional relationship with fruit-drop (Graph 5).

During the study period, the average temperature was 27.48℃. Throughout the study period, precipitation varied between 0.3 and 196.6 mm per week, with a total of 1102.32 mm over the entire period.

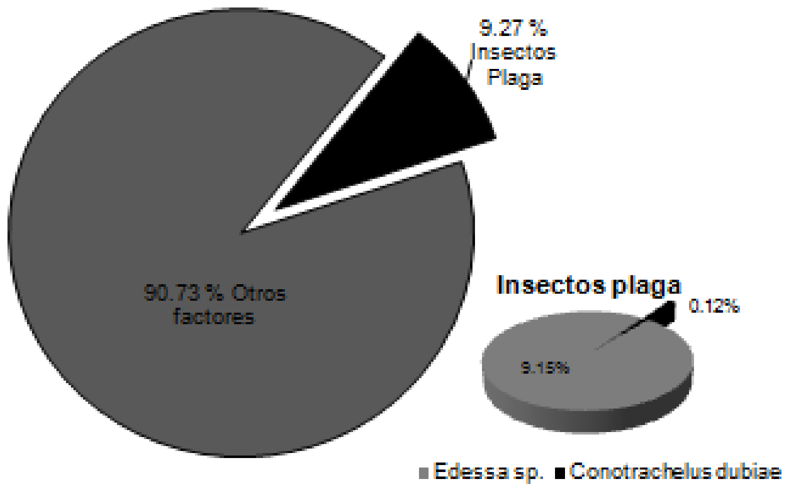
## DISCUSSION

In the experimental conditions of "restinga alta" (high levee), only 25.35% of green fruits reach a mature harvestable state. According to Inga et al. (2001), however, in natural stands, the same value rises as high as 27%. Higher levels of humidity and other physiological and sanitary factors that exist in natural stands could cause this difference.

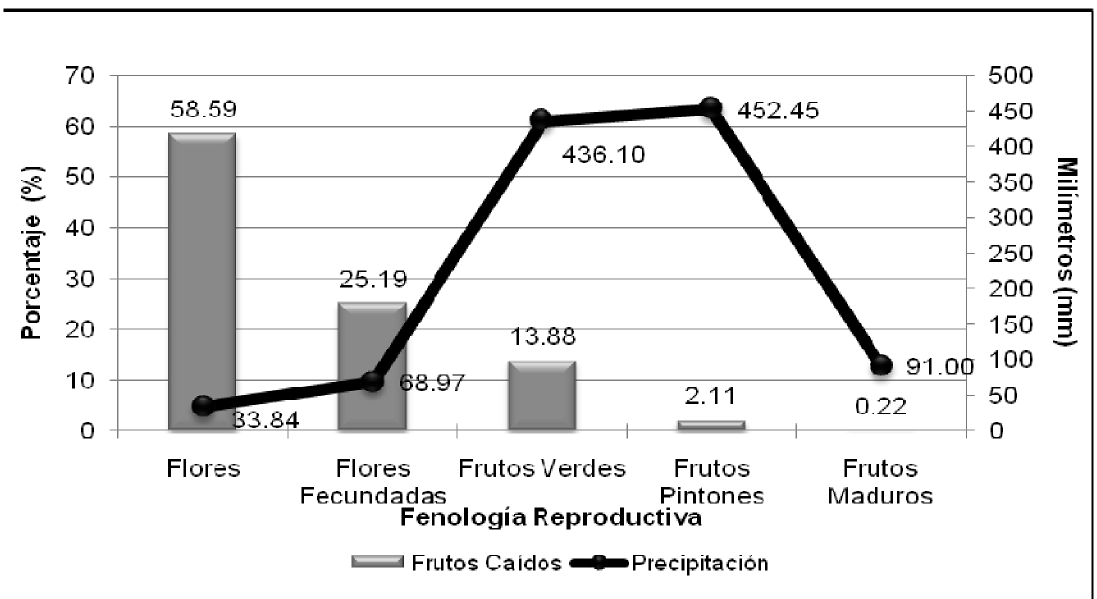
In our study, only 5.1% of differentiated flowers became mature harvestable fruits. Our finding falls within the margins reported by Imán (2000) of 4 to 12% persistence of flowers to mature harvestable fruit.

The critical stage for flower and fruit-drop took place during the first seven weeks of the study. Stoller (2009) explains that during the first weeks the cellular division and differentiation within each nascent fruit determines if it will stay on the tree or fall off pre-maturely.

The plants from the Putumayo River Basin had, on average, the lowest insect caused fruit-drop (5.51% of total fruit-drop for these plants), as opposed to those from




**Graph 3.** Causes of flower and fruit-drop in camu-camu.



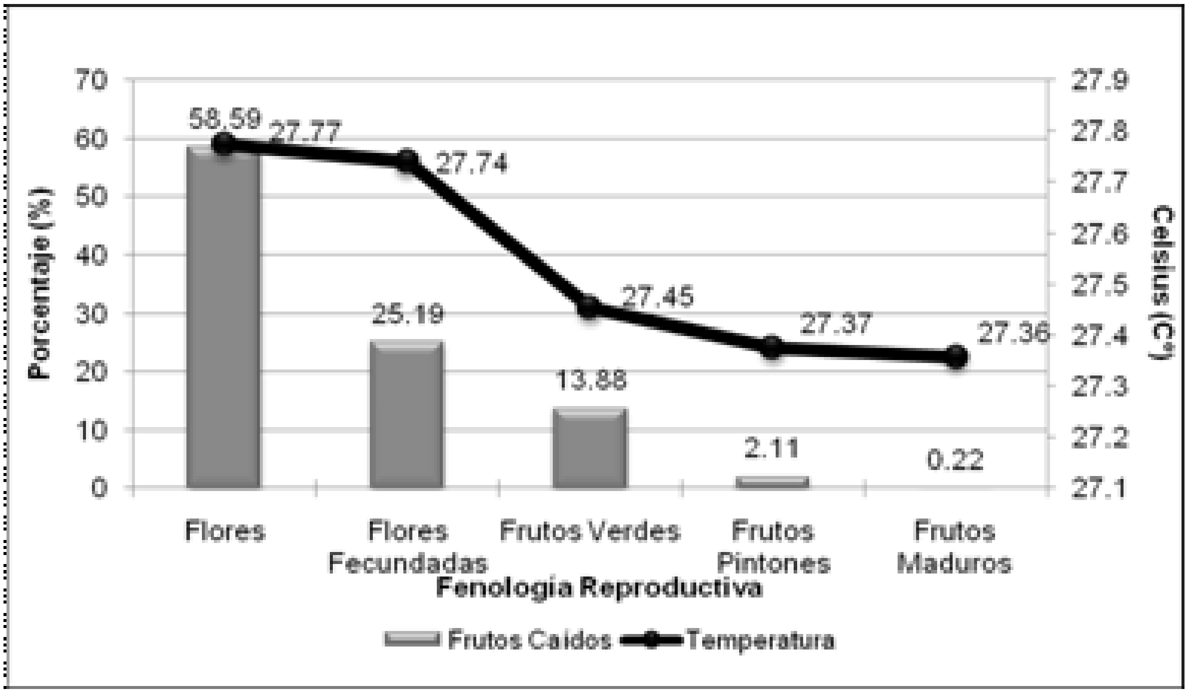

**Graph 4.** Flower and fruit-drop in relationship to phenological state and precipitation.

the Curaray River Basin, which at 11.78%, had the largest percent. Delgado and Couturier (2004), state that insect caused damage results in enormous losses to agriculture and the adults, larvae, nymphs or any combination of these stages, can cause such damage. In this experiment, adult *Edessa* sp. and *C. dubiae* and larval *C. dubiae* infested the plants.

## Influence of environmental factors

A direct relationship (76% correlation) was found between ambient temperature and flower and fruit-drop. No previous study has quantitatively demonstrated this relationship; however, Pinedo, Ramírez, and Blasco (1981) indicate that a strong relationship exists between temperature and the development of cultivated Arazá (Eugenia stipitata).

Camu-camu plants from the Putumayo River Basin had the highest level of environmentally caused number of fallen fruits and flowers (94.47%). This complex of environmental factors includes, amongst others, nutritional and physiological factors. Corroborating the studies of Pinedo et al. (2001), Riva and Gonzales




**Graph 5.** Flower and fruit-drop in relationship to phenological state and temperature.

(1999), and Peters and Vásquez (1986), we assume that environmental factors exist that affect the productivity.

According to Stoller (2009), during the summer or period of lower precipitation, many fruit trees experience fruit-drop. This occurs in the majority of fruit trees and the quantity of fallen fruit depends on the climatic conditions as well as the variety of fruit tree. In general, however, dehydration of fruits leads to a higher-level of fruit-drop during this period.

Similarly, Oliva et al. (2005) observed that in the majority of plants yields decreased significantly during the years 1998, 1999 and 2000. Oliva et al. (2005) indicate that this dip in yield occurred due to the effects of precipitation. During the months of January, May, September, and November of 1997, 363, 283, 188 and 161 mm/month of rain fell and in 1998 these values were 31.2, 171, 195 and 159 mm/month. Oliva et al. (2005) suggest that these lower precipitation values directly and significantly affected the reproductive phenology and as a result, caused the low yields.

## Factors effecting productivity

This study allows us to present data regarding fruit yield:

As compared to fruit from plants originating from the other four river basins, fruit from plants originating in the Putumayo River Basin had the greatest average weight (10.89 g). This confirms the findings of a Guillen and Pinedo’s (2007) previous study in the same study collection in which the fruit with the greatest average weight (7.6 g) came from plants originating from the Putumayo. The high level of hereditability (72%) of this characteristic (greater average fruit weight) (Bardales and Pinedo, 2009) makes plants from the Putumayo a potential source for genetic improvements of the species.

Plants from the Putumayo and Curaray River Basins had the highest average yields with 1614 and 1435 g/branch; this is closely related to the number of fruits and the average weight per fruit. Guillen and Pinedo (2007) stated that in the same germplasm bank the greatest average yield per plant was found in the plants from the Curaray.

## Conclusions

Fruit-drop in camu-camu is influenced by the presence of insect pests, which cause 9.27% of total loss (Edessa sp 9.15% and *C. dubiae* 0.12%). Natural abscission of flowers and fruit during the first three weeks of the reproductive phase (69.06%), and undetermined other factors (21.67%), including but not limited to physiological and nutritional factors, competition, wind, and rain, made up the remaining 90.73% of total loss.

We observed a directly proportional relationship between branch diameter and fruit and flower production. With respect to genetic factors (or origin of the plants), the Putumayo River Basin stands out as having the highest fruit retention (29.86%), and plants from the Curaray River Basin show the lowest retention rate (22.09%).

In cultivation of camu-camu, an average of 25.35% of green fruits remain on the branch and reach a mature harvestable state; however, when calculating retention from the flowering state only 5.1% of the formed flowers survive to become mature fruits.

The critical phase for flower and fruit-drop occurs in the first seven weeks of the reproductive phase. During the first three weeks, the majority of flower-drop occurs, and during the four subsequent weeks, the majority of fruit-drop occurs (at this point the fruit are in a small green stage).

Temperature exercises a directly proportional influence on the number of flowers and fruit that fall; as a result, as the temperature decreases so does the number of flowers and fruit that fall off the branch.

Pluvial precipitation shows an inversely proportional relationship to fruit-drop; thus, in periods of less precipitation, greater numbers of fruit and flowers fall off the plants. The number of fallen flowers and fruit decreases proportionately with increased precipitation.

In the Putumayo River Basin, favorable conditions (such as: greater average fruit weight, higher levels of fruit retention, greater resistance to insect plagues) exist which could be used in plans to genetically improve the species.

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