

# CLIMBING PLANTS IN THE FOSSIL RECORD: A CASE STUDY FROM PANAMA

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## Introduction

- Lianas (climbing woody plants, commonly known as vines) are important components of tropical and subtropical forest diversity, photosynthetic area, and canopy structure
- Liana abundance and diversity in the tropics is related to seasonality, disturbance, and pCO<sub>2</sub> (Schnitzer & Bongers, 2011)
- Fossil lianas can provide a record of forest structure and change in deep time; but recognizing them can be difficult
- Lianas generally have relatively large water-conducting vessels compared to trees and shrubs. Many liana stems also have unusual organization of the vascular cambium (Figure 1).
- Currently, only 19% of the megafossil record of lianas is made up of fossil wood and stems (Burnham, 2009)

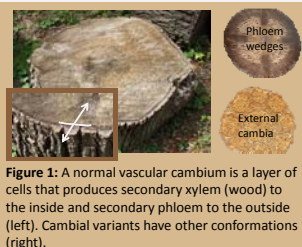


Figure 1: A normal vascular cambium is a layer of cells that produces secondary xylem (wood) to the inside and secondary phloem to the outside (left). Cambial variants have other conformations (right).

## Methods

- The fossil stems in this study were collected from the Lirio East site in the lower Cucaracha Formation (Fm.) along the Panama Canal
- The Cucaracha Fm. is a ~19Ma transitional-marine deposit (MacFadden et al., 2014)
- 18 out of 30 stems are included in this preliminary analysis
- Discriminant Analysis (DA) was performed in R to classify the fossils into either the climber or self-supporter group
- Discriminant analysis is a technique for classifying new observations into existing groups based on a training dataset where group membership is already known
- Here, the training data consists of measurements from ~80 modern stems (Ewers et al., 1990), the known groups are climber and self-supporter, and the variables are stem diameter and maximum vessel diameter; we classified 18 fossil stems from the Cucaracha Fm. into the two groups

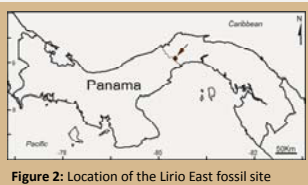


Figure 2: Location of the Lirio East fossil site

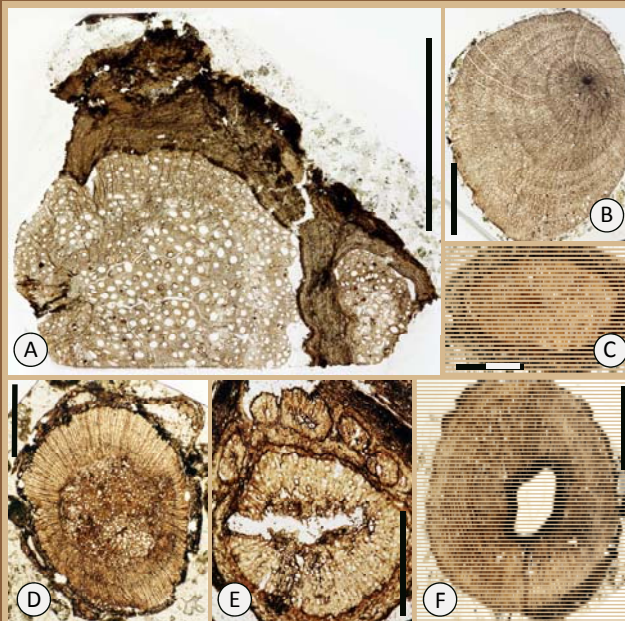


Figure 3: Cross sections of several Cucaracha stems. Thin sections were prepared using the cellulose acetate peel technique (Joy et al. 1956). A, Stem with large vessels and two external cambia, most likely of the genus *Serjania* (Sapindaceae), scale bar = 5 mm. B, Small tree or shrub stem with relatively small vessels, and indistinct growth rings, scale bar = 5 mm. C, Stem with intermediate-sized vessels and no cambial variants, scale bar = 1 mm. D, Small liana stem with external cambia, and small vessels, scale bar = 1 mm. E, Small liana stem with external cambia and small vessels, scale bar = 1 mm. F, Stem with hollow pith, intermediate-sized vessels, and parenchyma bands, scale bar = 2.5 mm.

## Results

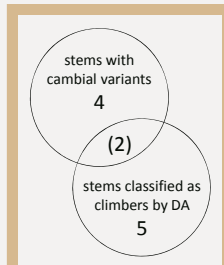


Figure 4: Venn diagram showing the number of fossil stems from the Cucaracha Fm. classified as lianas based on cambial variants, and the number classified as climbers by the DA.

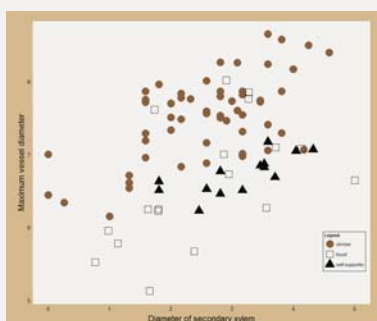


Figure 5: Plot of extant and fossil plants. Solid points comprise the training data taken from Ewers et al. (1990). Cross validation of the DA model yielded 87% correct classification. Squares are fossils allocated to either the climber or self-supporter group. All data were log-transformed.

## Discussion

- We combined the data from Figure 4, excluding the overlap, to provide a minimum estimate of liana density: 7/30 stems, or 23%
- The two fossils with cambial variants not classified as climbers by the DA (Fig. 4) fell outside the range of the training data; these may have been young lianas
- Many lianas start out as self-supporting plants until they reach a host (Rowe & Speck, 1996) and some mature lianas produce self-supporting searcher shoots that extend away from the host (Rowe & Speck, 2005)
- Young lianas or searcher shoots with normal cambia may be undetected by our methods

### Paleo-environmental context

- Rarity of growth rings in large wood fragments (trees) and stable isotope ratios in co-occurring mammal teeth indicate wet, aseasonal climate (MacFadden & Higgens, 2004)
- Anomalous growth rings in trees indicate rare growth interruptions
- Sedimentary evidence suggests volcanic activity was common (Herrera et al., 2014)
- The presence of horses, rhinos, and camels may also have been a source of disturbance



Figure 6: Lianas in Australia (cc)

## Conclusions

- Fossil lianas can be recognized by cambial variants and by their large vessels relative to stem diameter
- The abundance of lianas, together with data from vertebrate fossils, sedimentology, and tree rings provides strong evidence for a humid tropical forest with significant, intermittent disturbance during the Early Miocene in Panama